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A HYPOTHESIS OF BACTERIAL INFLUENCE IN THE GENESIS OF CERTAIN SULPHIDE ORES

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ABSTRACT

The work of previous investigators has shown that certain relatively stagnant lake and canal waters and some shallow ground waters are highly charged with hydrogen sulphide as a result of the reduction of soluble sulphates by certain anaerobic bacteria. Recent work by the present writer and his collaborators has shown that waters rich in hydrogen sulphide and carrying sulphate-reducing bacteria are associated with petroleum in several of the largest producing oil fields of Illinois and California.

If solutions carrying metals in balance with the sulphate, chloride, or bicarbonate radicles come in contact with such relatively stagnant hydrogen sulphide bearing waters, precipitation of the metals as sulphides must result.

Such a mechanism of precipitation is suggested as a hypothesis deserving of critical consideration in future studies of certain types of sulphide ores such as the *Kupferschiefer*, the copper deposits in red beds and other sandstones, and lead and zinc deposits of the Mississippi Valley type. A more complete summary will be found at the end of the paper.

THE HYPOTHESIS OUTLINED

In another article[1] the writer has directed attention to the prevalence of hydrogen sulphide in some natural waters including certain springs, lakes, ocean estuaries, portions of the ocean bottom, and certain bodies of ground water. The most notable described occurrences are the brackish canal waters of the Dutch coast, the Black Sea, the ground waters of the Dutch sand-dune areas, and

[1] Edson S. Bastin, with the collaboration of Belle Anderson, Frank E. Greer, C. A. Merritt, and Gail Moulton, "The Problem of the Natural Reduction of Sulphates," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. X, December, 1926.

the ground waters associated with petroleum in certain American oil fields. The prevalence of hydrogen sulphide in such waters is coordinated with an absence or paucity of sulphates. Earlier workers have shown that in the Dutch canals and ground waters, in the Black Sea (to depths of nearly 7,000 ft.), and on the ocean bottom, the presence of hydrogen sulphide is an effect of the reduction of soluble sulphates through the agency of anaerobic bacteria. The present writer and his collaborators in the paper referred to have shown that in certain oil-field waters, some of them from depths of over 3,000 feet, bacteria are present and are reducing sulphates with the formation of hydrogen sulphide. At least three species of sulphate-reducing bacteria have been isolated and described.

From such evidence as has been cited at length in the paper to which the reader is referred, it has become very clear that there are considerable bodies of surface waters and of ground water highly charged with hydrogen sulphide as a result mainly if not wholly of bacterial action. In view of the well-known potency of hydrogen sulphide in the precipitation of sulphides of the metals from solution the conclusion is obvious that such bodies of surface or of ground waters constitute a potential agency for the natural deposition of sulphides of the metals. Since the bacterial reduction may persist through long periods of time and the amount of hydrogen sulphide present at any one time is frequently sufficient to render the waters offensive and even toxic, the quantitative competence of the process for the precipitation of large amounts of sulphides can hardly be questioned.

It is the purpose of this paper to suggest such bacterial influence as an additional working hypothesis worthy of serious consideration by present and future workers in their study particularly of those sulphide ores that are associated with sedimentary rocks and have no apparent relation to igneous activity.

THE HYPOTHESIS APPLIED TO CERTAIN ORE TYPES

For the purposes of this discussion the ores deposit in which a bacterial influence in genesis is possible may be conveniently classified under the old terms "syngenetic" and "epigenetic." As syngenetic must probably be classed such deposits as the fossiliferous py-

rite beds of the Tully horizon in New York, and of Meggen in Westphalia, and probably the *Kupferschiefer* of the Mansfield region in Germany. The competence of hydrogen sulphide laden bodies of surface water, such as those of the Black Sea, to precipitate iron or copper from solution in the form of sulphides is beyond question, and in fact the Black Sea owes its name to the black iron sulphide that has been so precipitated. A number of European geologists have recently recognized the probable application of Black Sea conditions in the genesis of the *Kupferschiefer*, as has been well brought out by Parker Trask[1] in a review of recent views concerning those deposits. Once formed, such syngenetic sulphide deposits become a potential source of metals for the formation of epigenetic sulphide deposits through the agency of circulating ground waters.

Among the epigenetic sulphide deposits should be included the lead and zinc deposits of the Mississippi Valley region and the copper deposits in red beds and other sandstones in the southwestern part of the United States. For both these types of deposits and possibly for others a bacterial influence in precipitation is worthy of consideration as a working hypothesis, although obviously difficult to demonstrate fully in view of their ancient genesis, no bacteria perhaps remaining in the waters now associated with the ores.

In view of the recognition of sulphate-reducing bacteria and of hydrogen sulphide in the ground waters of the sand dunes of the Dutch coast, and in view of the common occurrence of fossil wood in the copper deposits in sandstone in Southwestern United States, it is entirely reasonable to suppose that the ground waters of the latter deposits carried sulphate reducing-bacteria and that the hydrogen sulphide formed by their metabolism promptly precipitated as sulphides any metals carried in solution in the ground waters. The hypothesis should be susceptible of partial verification by more critical study of these deposits, and it is entirely possible that in some of them sulphate-reducing bacteria are still present in the ground waters though probably not in their former abundance.

The lead and zinc deposits of the Mississippi Valley type offer a more complex and perplexing problem which will be considered at

[1] Parker D. Trask, "The Origin of the Mansfield Kupferschiefer, Germany. A Review of the Current Literature," *Econ. Geol.*, Vol. XX (1925), pp. 746–61.

more length. The district that has received the most careful study is the Tri-State District of Missouri, Kansas, and Oklahoma. Omitting any consideration of a number of theories that have now been generally abandoned, two contrasting views remain as to the genesis of these lead and zinc ores. The first and oldest is that expounded by Buckley and Buehler.[1] According to their conception, the metals of the present ore bodies were originally disseminated as sulphides through the overlying Pennsylvanian shale. During erosion of the shale these were oxidized, taken into acid solution, carried downward into the Mississippian limestones and cherts and there redeposited by the mingling of the acid solutions with neutral or alkaline solutions from other sources. The postulated mechanism of precipitation does not account adequately for the deposits now of greatest economic importance, which lie well beneath the Pennsylvanian capping. It is opposed also by the fact that in the downward enrichment of sulphide ore-bodies there is no evidence that lead, zinc, or iron can be precipitated as sulphides from descending sulphate solutions by simple neutralization.

The second hypothesis is that of Siebenthal,[2] which embodies, however, some features earlier presented by Bain. His report constitutes the most searching inquiry that has been made into the genesis of this type of ore deposit. While not accepted by all geologists familiar with the region, his conclusions as to the genesis of the ores appear to the present writer to co-ordinate much more fully than other hypotheses the facts of field occurrence. Briefly summarized, Siebenthal's conclusions are:

1. The mineralization is associated with the gently anticlinal Ozark uplift involving sediments as young as Pennsylvanian and having as its nucleus an area of pre-Cambrian crystalline rocks forming the St. Francis Mountains.

2. Nearly all the workable ore deposits occur in a belt a few tens of miles in width on the lower slopes of the uplift near the Pennsylvanian escarpment. A few unimportant deposits occur high-

[1] E. R. Buckley and H. A. Buehler, "Geology of the Granby Area," *Missouri Bur. of Geol. and Mines* (2d ser.), Vol. IV, (1906), pp. 78–110.

[2] C. E. Siebenthal, "Origin of the Zinc and Lead Deposits of the Joplin Region," *Bull. 606, U.S. Geolog. Surv.*, 1915.

er up on the slopes of the uplift. This distribution implies some control by this domal uplift over ore deposition. More specifically, it seems to imply a relation between ore deposition and the retreating edge of the Pennsylvanian formations.

3. The ores extend only to depths measured in a few hundreds of feet and are prevailingly "blanket" deposits.

4. Minor synclines on the flanks of the uplift are frequently the seats of maximum ore deposition. Fracturing also exerts a control.

5. Post-Cambrian vulcanism is extremely minor, and the mineralization has no obvious connection with such igneous activity. On the contrary, the mineralization is associated with silicification and dolomitization processes attributed to ground-water circulation.

6. A notable artesian circulation now exists down the western slope of the uplift in the region east of the larger ore deposits. A circulation similarly directed, acting through long periods, is believed to have been the agency that transported the metals.

7. The metals were dissolved, mainly as bicarbonates, through the weathering of minute grains of sulphides scattered through the older rocks of the central part of the Ozark uplift, and were redeposited as sulphides far down the flanks mainly beneath cappings of relatively impervious Pennsylvanian shales.

8. The present deep waters west of the main productive district and beneath the capping of Pennsylvanian shales are relatively stagnant, of high concentration, saline, and in many instances rich in hydrogen sulphide gas. They carry small amounts of metals, notably zinc, in solution, which on exposure in tanks or reservoirs precipitate as sulphides. The artesian waters that transported the ores are believed to have been similar to these in composition.

9. The agent of precipitation of the metallic sulphides was hydrogen sulphide gas. This was derived through the reduction of sulphates by *dead* organic matter in the sediment. While hydrogen sulphide was present throughout the entire sweep of the artesian waters down the slope of the Ozark uplift, it was prevented from functioning as a precipitant of the metals until the solutions became stagnant and acidity was reduced through escape of carbon dioxide.

Siebenthal's hypothesis of ore genesis has the merit of offering a reasonable explanation for the localization of many of the largest

deposits near the Pennsylvanian escarpment. There is difficulty however, in explaining by this hypothesis the large ore deposits well beyond the Pennsylvanian escarpment and beneath a considerable capping of Pennsylvanian shale. Finally, to the present writer, item 9 above, assuming a derivation of hydrogen sulphide through the agency of dead organic matter and postulating that hydrogen sulphide though present failed to function as a precipitant of the metals until considerable amounts of carbon dioxide had escaped from solution, has for some time appeared to be the weakest part of an otherwise reasonable hypothesis of ore genesis. In the remainder of the paper I desire to suggest certain modifications of the Siebenthal hypothesis based particularly upon the known functions of sulphate-reducing bacteria in the waters associated with oil fields.

No discussion of the geology of the Ozark uplift can be wholly adequate that does not take into account the immense accumulations of oil and gas that occur in its western flank and the evidences of the former presence of oil in the vicinity of the ore deposits. Figure 1, modified from Siebenthal's report, shows in broad terms the structural and stratigraphic features of the Ozark uplift. The edge of the Pennsylvanian formation, marking essentially the upper stratigraphic limit of mineralization, is indicated by dotted lines. Structure contours show for part of the region the elevation of the base of the Mississippi limestone above sea-level. The outlines of the principal oil fields have been added in dot and dash lines.

A noteworthy feature is the proximity of the oil fields to the principal mining district—the Tri-State District—in Missouri and adjacent portions of Kansas and Oklahoma. Most of the production from these oil fields has come from the Pennsylvanian, but within recent years an increasing amount has come from the Mississippian, including the particular horizon—the Boone chert—that is the principal zinc-producing horizon farther east.[1] In north Texas, also, the Mississippian is a very important oil-bearing horizon.

A second feature of the region whose significance has not been fully appreciated is the abundant presence of heavy oil and bitumen in association with many of the ores of the Tri-State District.

[1] See T. O. Bosworth, *Geology of the Mid Continent Oilfields* (1920), pp. 52–54.

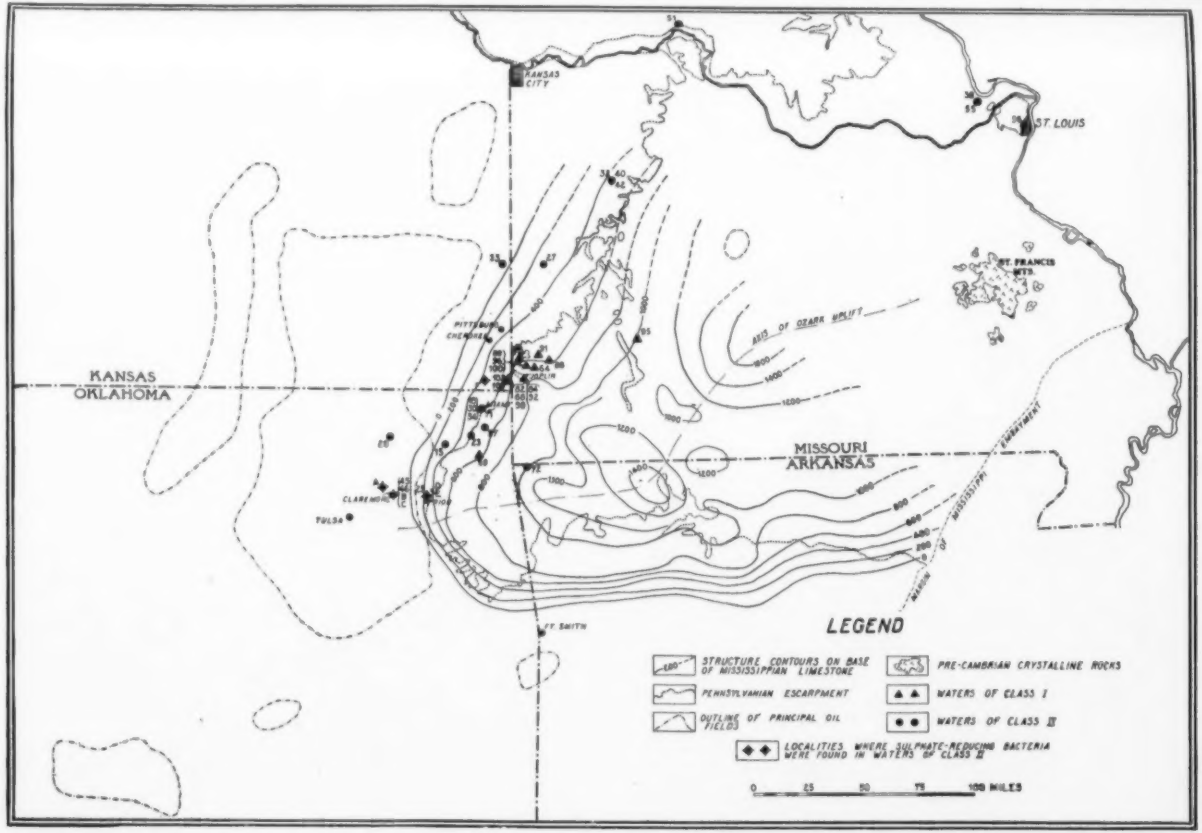

FIG. 1.—Generalized map of the Ozark uplift

Siebenthal mentions its occurrence but attributes no significance to it in the process of ore formation. He says:

> At a place known as Tar Spring, on Tar Creek, about 6 miles north of Miami, Okla., a heavy bitumen oozes in considerable quantity from the bank of the creek at the contact of the Pennsylvanian (Cherokee) shale and the lower rocks. In the mines at Miami the sandstones and limestones of Chester age at the same geologic horizon, the base of the Pennsylvanian shale, are impregnated with bitumen, which, as has already been noted, interferes seriously with the concentration of the lead and zinc ores occurring in the same sandstone. In the same mines bitumen also oozes from crevices in chert of the Boone formation below the Chester rocks. The bitumen sometimes interferes greatly with prospecting by the churn drill. Bitumen occurs in limestone of Chester age at the base of the Pennsylvanian shale just west of Afton, Okla., and also in pockets in the Boone formation in association with the ore deposits of the Joplin region generally [pp. 205–6].

According to Winslow,[1] bitumen

> is found principally in the breccia of the ore bodies of the southwestern district. It also occurs there in cavities of the country rock. Sometimes the rock or gangue is completely saturated with it and the quantity is considerable. It is generally a brownish red or black fluid which hardens on exposure.

According to E. S. Perry,[2] one shaft 4 miles northwest of Quapaw, in the Tri-State District, had to be abandoned because of the large influx of thick oil at the ore horizon—below the Pennsylvanian Cherokee shale. In treating some of the ores near Commerce, Oklahoma, kerosene was used in the milling process to dissolve the tar.

With reference to the uppermost Mississippian rocks of northwestern Arkansas and southwestern Missouri, Mr. E. T. Thomas writes:

> The Hindsville limestone and the Batesville sandstone were and still are petroliferous over quite large areas. About four miles south of Prairie Grove, Arkansas, the abundance of oil in the Weddington sandstone member of the Fayetteville shale has led to the application of the name "Oil Spring Locality."[3]

According to R. V. Ageton, of the Tri-State Zinc and Lead Producers Association,[4] bituminous material is of fairly constant occurrence in the Tri-State zinc and lead field along certain horizons, usually at depths around 185 feet. It is especially abundant in the

[1] Arthur Winslow, "Lead and Zinc Deposits," *Missouri Geol. Surv.*, Vol. VII, 1894.

[2] Personal communication.

[3] Personal communication.

[4] Personal communication.

central part of the field. It was noted by Bastin in abundance on several mine dumps at Picher, Oklahoma, notably La Salle No. 2 Mine, where some is fluid enough to run on a hot day and all is decidedly sticky. In this mine drips of oil from the roof at the faces are common. According to Ageton, methane is common in the mines of the northwestern part of the field.

These heavy oils and bitumens must be interpreted as residuums from the evaporation of petroleum. Their presence is indicative of the abundant former presence of petroleum in the porous rocks beneath the Pennsylvanian capping east of the present oil fields and in the localities that are now ore bearing.

The presence of hydrogen sulphide today in a few mines and in many artesian wells of the region should be emphasized. According to Siebenthal:

> The mine water at Miami first pumped was highly charged with hydrogen sulphide, and in early days, when the mine drifts were small, the gas was so strong as to affect the eyes of the miners, who could therefore work only in half-day shifts, or, when the gas was very strong, in half-hour shifts. As mining was continued and as the underground workings were made larger, the hydrogen sulphide was hardly noticeable except in new and small drifts at some distance from the old workings [pp. 203–4].

Hydrogen sulphide in small amounts was noted by Bastin in three mines of the Tri-State Zinc and Lead District, the Bob White, the Underwriter's Land Company No. 7 (shaft No. 2), and the Federal Jerett Mine (South Field shaft). The artesian waters from below the Pennsylvanian capping in the region west of the Tri-State Mining District characteristically carry some hydrogen sulphide.

Finally, attention should be directed to significant resemblances in composition between the ground waters in the lead and zinc district and those in certain productive oil fields where sulphate-reducing bacteria are functioning today. The ground waters of the western slope of the Ozark uplift in the general vicinity of the zinc and lead deposits may be grouped in three classes.

Class I.—To this class belong waters of low concentration (110–1,000 P.P.M.), high in earths and low in alkalies among the basic radicles, and high in carbonate and sulphate and low in chlorine among the acid radicles. Analyses 108, 101, and 98 of Siebenthal's

report are selected as fairly representative of this class, and are shown graphically in Figure 2, in terms of reacting values of the various radicles in percentage, calculated according to Palmer's method.[1] The class comprises spring, well, and mine waters of that part of the Ozark uplift lying at or inside of the Pennsylvanian escarpment. Some of the mine waters, particularly in the eastern part

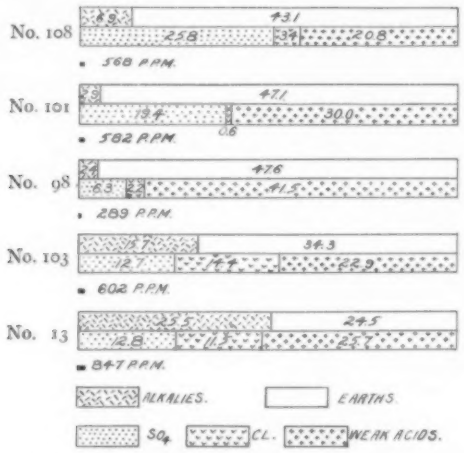

FIG. 2.—Graphs of representative waters of Classes I and III showing reacting values in percentage computed by the Palmer method. Numbers correspond to Siebenthal's report. Heavy black lines show concentrations in parts per million.

108—Sphalerite Well, Aurora, Mo.
101—B. and C. Mine, Joplin, Mo.
98—Freeman Foundry Well, Joplin, Mo.
} Class I

103—Waterworks Well No. 3, Pittsburg, Kan.
13—Waterworks Well, Cherokee, Kan.
} Class III

of the Tri-State District near Joplin and Webb City, belong to this class. These waters are never characterized by hydrogen sulphide. Their relatively high proportion of sulphate should be particularly noted.

Class II.—These are predominantly sodium chloride waters rich in alkalies among the basic radicles and high in chlorine but low in

[1] Chase Palmer, "Geochemical Interpretation of Water Analyses," *Bull. 479, U.S. Geol. Surv.*, 1911.

sulphates among the acid radicles. Their concentration is highly variable, ranging from around 400 to 37,500 P.P.M. The more concentrated members of this class closely approach sea water both in concentration and in the proportions of their components. Siebenthal's Nos. 15, 25, 46, and 30 are representative of this class, and are shown graphically in Figure 3 with the graph of normal sea water for comparison. A few of the waters of this class, as exemplified by No. 15, are alkaline, the alkalies exceeding the strong acid radicles in reacting value. It should be particularly noted that the waters of this class are poor or lacking in sulphates, indicating that reduction of sulphates has been in progress. Hydrogen sulphide, the product of such reduction, is present in essentially all of these waters in amounts ranging from 1 to 118 P.P.M. The waters of this class are interpreted by Siebenthal as connate, a conclusion in which the present writer concurs. Many mine waters of the western part of the Tri-State field beneath the Pennsylvanian capping are of this type, in contrast to those of the eastern part of the field, which belong characteristically to Class I.

It is instructive to compare the graphs of these waters with similarly constructed graphs of waters from the Coalinga and Sunset-Midway fields, California, and from three Illinois oil fields, all of which carry abundant sulphate-reducing bacteria. These are shown as Nos. *C*-1, *C*-32, *I*-1, *I*-16, and *I*-27 in Figure 3. Their similarity to the Ozark waters is obvious.

Class III.—A few waters from the west flank of the Ozark uplift in the general vicinity of the Pennsylvanian escarpment are intermediate in composition between the waters of Classes I and II, and are probably the result of their commingling. Siebenthal's Nos. 13 and 103 are representative, and are shown graphically in Figure 2.

From this discussion it is evident that the largest and most important of the ore deposits of the Ozark uplift, those of the Tri-State District, lie near the contact zone between bodies of ground waters notably different in composition. On the west, well beneath the Pennsylvanian capping, are relatively stagnant waters (Class II) characterized by large proportions of sodium chloride and in some instances by a salinity greater than that of ocean water. Their low sulphate content (below that of sea water) and their content of

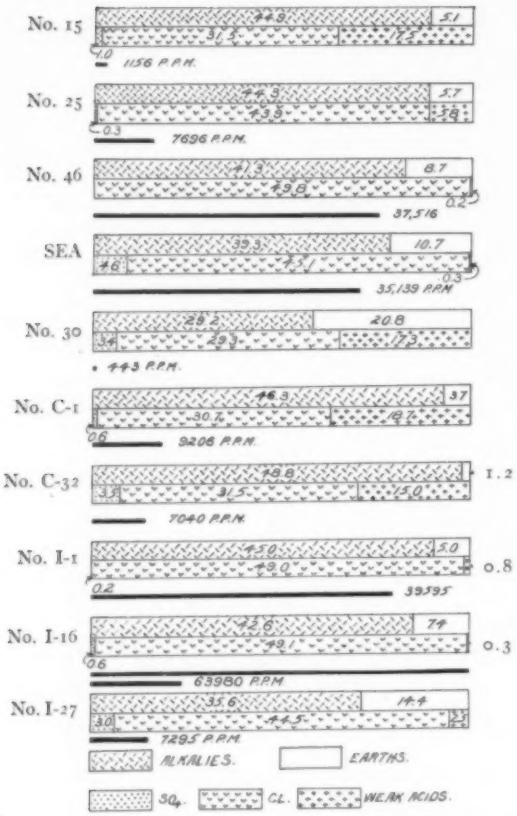

FIG. 3.—Graphs of representative waters of Class II with sea water and California and Illinois oil-field waters for comparison. Reacting values in percentage computed by Palmer method. Numbers for first four analyses correspond to Siebenthal's report. Heavy black lines show concentrations in parts per million.—

15—Frisco Well, Vinita, Okla.
25—Whitaker Park Well, Prior, Okla.
46—Radium Well, Claremore, Okla.
Sea—Dittmar's average for sea water.
30—Chapman and Lennan Mine water, Miami, Okla.
C-1—Well No. 3, Sec. 25, T. 20 S., R. 14 E., Coalinga, Calif.
C-32—Ida May Water Well, Sec. 2, T. 11 N., R. 24 W., Maricopa, Calif.
I-1—A. J. Bigelow Well No. 10, Clark Co., Ill.
I-16—Laura Gillespie Well No. 4, Lawrence Co., Ill.
I-27—A. Gaertner Well No. 5, Waterloo Field, Ill.

hydrogen sulphide is clearly indicative of a reduction of sulphates. Waters in the westernmost mines of the district belong in the main to this class. On the east, at and inside the Pennsylvanian escarpment, the ground waters (Class I) are fresh and carry relatively large proportions of sulphates. They are free from hydrogen sulphide. Many mine waters near Joplin and Webb City belong to this class.

This situation finds a fairly close analogue in the Sunset-Midway oil field of California, where relatively dilute waters of surface origin and containing a large proportion of sulphates are moving down dip into contact with brines notably low in sulphates and carrying hydrogen sulphide. In the Sunset-Midway and Coalinga oil fields and in three of the Illinois oil fields such brines carry an abundance of sulphate-reducing bacteria.

PARTIAL CONFIRMATION BY FIELD STUDIES

The studies of Siebenthal and others indicate that most of the lead and zinc ores now worked were deposited long ago, and that ore deposition if operative today is confined to regions lying west of the Tri-State District and at considerable depths below the surface. The chances of verifying the bacterial hypothesis of genesis through field studies seemed therefore unpromising. Nevertheless the presence of minor amounts of hydrogen sulphide in the waters of Class II suggested that some sulphate-reducing bacteria might still be present, although presumably this gas might persist for considerable periods after the death of the organisms that formed it or might migrate some distance from its point of origin. Accordingly, a brief field trip was undertaken by the writer in September, 1925, to collect samples of mine and well waters for bacterial study. The water samples were collected by the same methods used in the oil fields, and described in the paper by the writer and his associates already referred to. The bacterial tests were made by Dr. Frank Greer in the Bacteriological Laboratory of the University of Chicago.

For the waters of Class I—fresh waters high in sulphates—negative results were to be anticipated, and only three samples of this class were collected, as follows:

1. Webb City waterworks, 2 miles north of Webb City, Missouri; pumping well, 858 feet deep

2. United Iron Works [Old Freeman Foundry] well, Joplin, Missouri [No. 84 of Siebenthal]
3. Bob White Mine, 2 miles west of Picher, Oklahoma

None of these showed sulphate-reducing bacteria.

For the waters of Class II, sodium chloride waters commonly carrying small amounts of hydrogen sulphide, a much larger number of samples were collected, most of them from free-flowing artesian wells, but two from mines.

Negative results were obtained on the following samples:

Artesian well waters:
- 2 from Clinton, Missouri
- 1 from Deerfield, Missouri
- 1 from Afton, Missouri
- 2 from Miami, Oklahoma
- 1 from Vinita, Oklahoma

Mine water:
- 1 from Federal Jerett Mine, South Field shaft, Tri-State District

Positive results were obtained on the following samples:

Artesian well waters:
- 1 from between Claremore and Collinsville, Oklahoma
- 2 from Claremore, Oklahoma
- 2 from Pryor, Oklahoma

Mine waters:
- Underwriter's Land Company Mine No. 7 [No. 2 shaft] near Treece, Kansas

The waters yielding positive bacterial results are considered in more detail below. In all the media, soluble ferrous salts were used as an indicator of hydrogen sulphide. As soon as hydrogen sulphide was developed by the bacterial reduction it combined with the ferrous salt to produce black sulphide of iron. In the liquid media this appeared as a black precipitate, and in the solid media it colored the globular colonies black. Since most of the waters carried H_2S when collected, it was necessary to remove this by exhaustion in sterile vacuum desiccator before inoculations were made. After such treatment there was no black coloration of the media on inoculation, and all subsequent blackening was attributable to bacterial generation of hydrogen sulphide.

Sample A.—This sample was taken from a free-flowing well about midway between Collinsville and Claremore, Oklahoma (Fig.

1) in Sec. 21, T. 22 N., R. 15 E. A large volume of water rises from an uncased drill hole into a shallow pool. The sample was taken by opening the bottle under water where the flow was most active. Taste, fairly salty. Strong odor of H_2S. No reaction for sulphates with $BaCl_2$. Eight days after inoculation liquid medium No. 1.1 showed in duplicate a moderate black precipitate and solid medium No. 1.3 in duplicate was filled with coalescing black colonies.

Sample B.—This sample was taken from an artesian well at Sequoya Hotel and Radium Baths, Claremore, Oklahoma (Siebenthal's No. 46; see Figs. 1 and 3). The sample was taken from the pipe at the collar of the flowing well discharging continuously into the tank. Taste, strongly salty. Distinct odor of H_2S. No reaction for sulphates with $BaCl_2$. Eight days after inoculation liquid medium No. 1.1 showed in duplicate a moderate black precipitate and solid medium No. 1.3 in duplicate was two-thirds filled with a coalescing growth of black colonies.

Sample C.—This sample came from an artesian well supplying the Sanitarium Bath House, Claremore, Oklahoma. Depth, between 1,200 and 1,300 feet. Sample from end of sealed lead line. Constant, vigorous flow. Taste, strongly salty. Strong odor of H_2S. No reaction for sulphates with $BaCl_2$. Eight days after inoculation liquid medium No. 1.1 showed, in duplicate, a slight black precipitate.

Sample D.—This sample came from Whittaker Park artesian well (analysis 25 of Siebenthal). Continuously flowing. Sample from valve at casing head. Depth, 600 feet. Taste, slightly salty. Odor of H_2S. No reaction for sulphate with $BaCl_2$. Waters depositing calcium carbonate. After eight days liquid medium No. 2.2 showed, in duplicate, a slightly black precipitate.

Sample E.—This sample came from an artesian well on F. L. Higgins' farm $1\frac{1}{2}$ miles north of Pryor, Oklahoma. Depth, about 1,200 feet. Sample from casing head standing 5 feet above ground, from which water is constantly flowing in large volume. Taste, slightly salty and bitter. Odor of H_2S. No reaction for sulphate with $BaCl_2$. Deposit of calcium carbonate around well. At end of eight days liquid medium No. 2.2 showed a slight black precipitate in one of the duplicate cultures.

Sample F.—This sample came from Mine No. 7 (No. 2 shaft) of Underwriter's Land Company, 2 miles northwest of Treece, Kansas, Tri-State Zinc District. Water flowing from ore in roof of short drift at depth of 327 feet below surface. Taste, not appreciably saline. Distinct odor of H_2S. Slight clouding with $BaCl_2$ shows presence of some sulphate. Inflammable gas, presumably methane, occasionally encountered in small amounts. At the end of four days liquid medium No. 1.2 showed in duplicate samples a moderate black precipitate becoming profuse by the sixth day.

In view of the free-flowing character of the wells yielding sulphate-reducing bacteria, there can be little doubt but that these anaerobic organisms came from the artesian-water horizon and were not the result of surface contamination. The number of bacteria present is evidently small as contrasted with the Illinois and California oil-field waters that were earlier tested. This is to be expected in view of the absence of recognizable amounts of oil in these waters, petroleum being the probable source of energy for the bacterial reduction of the sulphates. To the writer it appears probable that more numerous cultures made promptly in the field would reveal the presence of these organisms in the waters of Class II that yielded negative results in this series of tests.

A final test of a hypothesis of bacterial influence in the formation of lead and zinc ores of the Mississippi Valley type must of course involve a detailed consideration of the deposits of southwestern Wisconsin and adjacent parts of Illinois and possibly also a consideration of the Silesian deposits in Europe. However, for these regions, no studies of the composition and movements of the ground waters analogous to Siebenthal's in the Ozark uplift have been made, and such studies form an essential basis for a critical discussion. At present it seems worth while only to direct attention briefly to a few features of these deposits that appear significant and suggestive in connection with a bacterial hypothesis.

In the Wisconsin-Illinois region the ore-bearing horizon, the Galena dolomite, is a relatively porous formation bordered by relatively impervious shales above and below. It has been generally recognized as a favorable vehicle for an artesian circulation. At the base of the Galena dolomite occurs a thin bed of oil shale which has a

petroleum odor and in places carries sufficient bituminous matter to burn when dry. Nearly all students of the region have attributed to this oil shale a rôle in the deposition of the ore. It must be regarded as a possible source of petroliferous matter for the support of sulphate-reducing bacteria in adjacent ground waters. The more important ore-bodies are contiguous to this oil shale. Of particular significance is the statement by Grant[1] that hydrogen sulphide "is found to be a rather constant constituent of the deep-seated waters in this region." He attributes to it a rôle in the precipitation of the ores.

As regards the lead and zinc deposits of Silesia, the following summary statement from Beyschlog, Vogt, and Kruschs' *Ore Deposits* is noteworthy:

> It may be regarded as established that the ores were deposited from solutions which, circulating within the Muschelkalk beds, effected their dolomitization. At the same time a gradual replacement of the limestone by ore took place, as well as a crusted deposition in chambers previously formed by the dissolution of the dolomite and limestone. The not-infrequent occurrence of stalactites and the abundant occurrence of schalenblende indicate this latter manner of formation. The pocket-like occurrence of the ore in holes like pot-holes in the limestone floor suggests rapidly flowing water. The apparent limitation of the ore-beds to one or two often well-maintained horizons is adequately explained both by the physical behavior of these particular beds towards inflowing water, as well as metals in solution. Against solid compact layers such water would be impounded. Where several of such layers occurred several ore-beds would be formed one above the other, in number corresponding to the number of such water reservoirs. At the same time the bitumen, which is still discernible in some beds, may have acted as the agent whereby the sulphates present were reduced to sulphides.[2]

SUMMARY AND CONCLUSIONS

In a previous paper by the writer and his collaborators it is shown that in the ocean and in certain lakes, in some river and canal waters, and in some ground waters certain anaerobic bacteria are actively engaged in the reduction of soluble sulphates with the formation of abundant hydrogen sulphide. In the Black Sea this process is operative to depths of nearly 7,000 feet, and in the Cali-

[1] U. S. Grant, "Preliminary Report on the Lead and Zinc Deposits of Southwestern Wisconsin," *Bull. IX, Wisconsin Geolog. and Nat. Hist. Survey* (1903), p. 82.

[2] *Op. cit.* (Eng. trans.), Vol. XI (1916), pp. 728–29.

fornia oil fields to depths of over 3,000 feet. The process is particularly active in the waters of certain oil fields, the petroleum apparently functioning as a necessary food element supplying the energy required for sulphate reduction.

Upon the basis of these facts there is advanced as a working hypothesis the conception that such bodies of surface water or ground water charged with hydrogen sulphide through bacterial action are situations where sulphides of the metals will be precipitated if brought in by other solutions.

The applicability of the hypothesis of such syngenetic deposits as the *Kupferschiefer* is suggested, and in fact the probable analogy between the conditions of genesis of those ores and present conditions in the Black Sea has already been recognized by several European geologists.

Among the epigenetic sulphide ores, the applicability of the hypothesis to such ores as the copper ores in red beds and other sandstones and to the Mississippi Valley type of lead and zinc ores is suggested.

Siebenthal's careful studies of the zinc and lead ores of the Ozark uplift furnish an adequate basis for critical discussion of the applicability of the bacterial hypothesis in that region. The present contiguity of the largest ore district—the Tri-State District—to the great oil fields of Kansas and Oklahoma is emphasized. A previous eastward extension of these oil fields to the vicinity of the present ore deposits is suggested by (1) the porosity of the ore-bearing rocks. (2) the abundance of heavy oil and bitumen in many of the ores, and (3) the similarity of the present deep waters below the Pennsylvanian shale capping to the waters associated with petroleum in several of the Illinois and California fields. In these oil fields the waters under discussion carry abundant sulphate-reducing bacteria and abundant hydrogen sulphide as a product of the bacterial reduction. The similar waters of the lead and zinc district also carry hydrogen sulphide, though in less abundance, and in some of them sulphate-reducing bacteria are present.

These relations suggest the presence in the vicinity of the present ore-bodies, at the time of their formation, of a relatively stagnant body of connate water probably resembling in composition and con-

centration the deep artesian waters at Claremore, Oklahoma (No. 46, Fig. 3), and hence resembling also sea water and the bacterial waters of the Illinois and California oil fields. With these waters was associated petroleum in sufficient amounts to furnish ample food for sulphate-reducing bacteria.

Fresh waters of superficial origin, carrying large percentages of sulphates, moving down the dip of the Ozark uplift, would meet the connate salt waters in the general vicinity of the present ore-bodies. Where the two waters mingled the optimum conditions for the growth of sulphate-reducing bacteria would obtain, namely: (1) the presence of organic food in the form of petroleum (and possibly natural gas), (2) salinity, and (3) a constantly renewed supply of sulphates. In such a zone, as is the case in the Sunset-Midway oil field today, the generation of hydrogen sulphide would be particularly active. The zone of mingling of waters, of active bacterial growth and hence of active hydrogen sulphide generation and of ore deposition, would begin at the Pennsylvanian escarpment but would persist for considerable distances beneath the capping of Pennsylvanian shales.

The bacterial hypothesis deals primarily with the mechanism of deposition of the metals, but it involves indirectly the problem of their source, since it implies their presence in the ground waters in a form precipitable by hydrogen sulphide. It rules out solutions in which the metals are already in balance with the sulphur radicle and hence probably rules out a *direct* magmatic source. From balance with the sulphate, chlorine, and bicarbonate radicles the metals would be promptly precipitated by hydrogen sulphide. Siebenthal believes that the metals were contributed by a deep artesian circulation descending the flanks of the Ozark uplift and rising again in the vicinity of the Pennsylvanian escarpment and the present ore deposits. Whether or not this was the main source, some contribution of metals from surficial waters descending the flanks of the Ozark uplift would appear almost inevitable. With progressive erosion of the Ozark uplift, a progressive outward migration of the zone favorable for bacterial growth and hence for ore deposition would be expected. With such erosion and shifting of the zone of deposition, earlier-formed ores would be exposed to the attack of surficial waters, their

metals redissolved and carried downward to be redeposited farther out on the flanks of the uplift where hydrogen sulphide was still abundant.

The conditions surrounding the present ore deposits may be regarded as the "diluted" counterpart of those existing at the time of ore deposition, the waters now associated with the ores carrying salts, petroleum, sulphate-reducing bacteria, and hydrogen sulphide much less abundantly than at the time the ores were deposited. It is probable, however, that some ore deposition is still in progress, particularly far beneath the Pennsylvanian capping.

In the upper Mississippi Valley lead and zinc district the groundwater circulation has not been critically studied. The proximity of the larger ore-bodies to an oil-shale horizon and the presence today of hydrogen sulphide in the deeper waters of the region are suggestive, however, of a bacterial rôle in ore precipitation.

"ABNORMAL" SHORE PLATFORMS

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Conditions in New Zealand are especially favorable to the study of shoreline forms, and, probably for this reason, New Zealand geologists are impressed with the frequency with which subhorizontal benches are developed near high-water level on rocky, retrograded coasts, and, whatever individual beliefs may be held as to their origin, discussions have made it obvious that local geologists are strongly of the opinion that such benches are a far commoner feature than the literature would lead one to expect.

The present paper aims at briefly discussing shore platforms which make a distinct departure from the profile which has been described as the "normal shore profile," or the "profile of equilibrium," and for this reason only has the term "abnormal" been applied to them in the title of this paper. The writer firmly believes that such platforms are in no respect truly abnormal, but that characteristically they are expectable, and therefore the normal products of shoreline erosion, and is assured by correspondence that his is no isolated belief.

Ten years ago the writer published a brief paper on certain rock platforms which are a prominent and characteristic feature of shoreline topography in many harbors of North Auckland, and of which an outstanding example is afforded by the well-known "Old Hat" near Russell in the Bay of Islands, New Zealand.[1] As with most other North Auckland harbors, the Bay of Islands has been formed by the submergence of a maturely sculptured land-mass, and the Old Hat, which is illustrated in Figure 1, represents an emergent portion of a submerged spur.

Rock benches of the Old Hat type are barely covered by mean

[1] J. A. Bartrum, "High-Water Rock-Platforms: A Phase of Shore-Line Erosion," *Trans. N.Z. Inst.*, Vol. XLVIII (1916), pp. 132–34.

high tides; they vary in width from a few feet to 30 yards or more, and have a surface which is essentially horizontal but for minor irregularities. At their seaward margins there is a steep descent for a few feet, while landward they extend to the base of fairly lofty sea-cliffs, the material of which is generally distinctly weathered. It was pointed out[1] how these shore platforms interrupt the normal shore

FIG. 1.—The "Old Hat," Russell, Bay of Islands, N.Z. The line of drift wood on the beach delineates high tide mark. (Photo by Winklemann.)

profile, which "is a compound curve which is concave near the shore, passing through a line of little or no curvature to a convex front."[2]

The rapid descent of the edges of the benches under discussion appears not to be a heritage of initial drowned topography, for at some headlands the sea-cliffs have retreated so far that the spur slopes above them are now reversed. It is believed rather to be the result of the attempt of the waves to produce a shore profile of the normal type.

In his masterly study of shore processes, Johnson (1919) does

[1] *Ibid.*

[2] N. M. Fenneman, "Development of the Profile of Equilibrium of the Subaqueous Shore Terrace," *Jour. Geol.*, Vol. X (1902), pp. 1–32.

not discuss other than very temporary departures from the profile of equilibrium; he expressly states, however (p. 221), that

> . . . . extended discussions have been carried on and numerous erroneous laws of shoreline activity have been laid down, all based on observations of minor fluctuations in the shore profile of equilibrium. This has been unfortunate. . . . . It has concentrated attention on the less important details of shore activities, and caused neglect of the broader fundamental aspects of coast erosion.[1]

Nevertheless, it must be emphasized that failure to realize that the so-called normal shore profile of equilibrium is not a universal one has led in certain instances to erroneous conclusions regarding recent minor changes of sea-level, and understanding of other phases of shore profile is essential if repetition of such errors is to be avoided.

Dana (1849) first brought shore benches of the Old Hat type into scientific prominence, and, in explaining their origin, ascribed great importance to the protection from subaerial weathering afforded rock below sea-level compared with that above. Somewhat inconsistently, however, he went on to state that the actual height of the surface of the platforms above high-tide mark is dependent upon what he called "the level of greatest wear." This latter he showed to be dependent mainly on wave height but partly on tidal interval. His statement, "Above the material has disintegrated and been washed away by the action of streamlets and the waves; but beneath the water these effects do not take place,"[2] was taken by the present writer to mean that Dana visualized a laterally extensive zone of weathered rock lying above sea-level, which was removed as the shoreline retrogressed. His own observations showed that a delicate balance existed between the vigor of wave erosion and the survival of the platform, so that at somewhat less-sheltered coasts, where the waves were moderately powerful, the "normal" shore profile was developed and no trace of shore platform existed. This result seemed inconsistent with Dana's hypothesis that such benches reflected the existence of "a level of greatest wear," and the writer therefore suggested[3] that the platforms are the product, not so much

[1] The writer has not had an opportunity of seeing this author's most recent study, *The New England–Acadian Shoreline* (New York, 1925).

[2] J. D. Dana, *Repl. U.S. Expl. Exped., 1838–42*, Vol. X, *Geology* (1849), p. 442.

[3] J. A. Bartrum, *op. cit.*

of wave attack upon a definite zone of weathered rock, as of the progressive destruction of the cliff faces by subaerial erosion down to the level of permanent saturation (a little below mean high-water level), while weak waves removed the products of disintegration and so permitted a landward migration of the ground-water table, and hence of the inner limit of the zone of weathering, in harmony with the retreat of the base of the cliffs. The steep slope on the outer or seaward edge of the platform so developed is interpreted then as part of the normal shore profile carved from more resistant unweathered

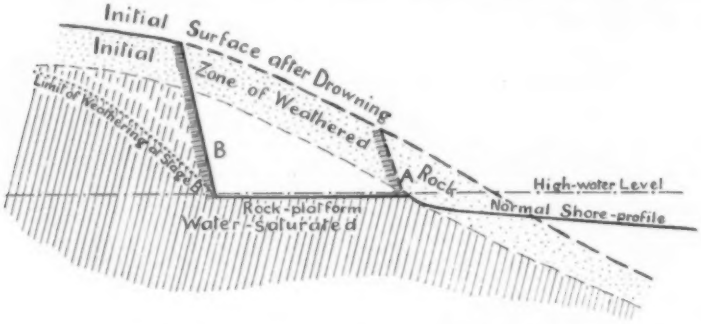

FIG. 2.—Section diagram illustrating the development of high-tide rock platforms.

rocks below high-water level. The accompanying section-diagram (Fig. 2), reproduced from the writer's original paper, while disregarding many minor aspects, illustrates this hypothesis so far as major details are concerned. It shows that a platform originating thus could be initiated only when the cliffs had retreated sufficiently to expose unweathered rock beyond the initial zone of weathering (stage *A* in the diagram), and demonstrates further how the general considerable height of these latter is a necessary consequence of this fact.

It is possible that Dana's conception involved similar progressive recession of the cliff faces by weathering, for his statement is indefinite, but neither he nor Hochstetter[1] (1864), who described shore platforms near Auckland, appears to have realized that they

[1] F. von Hochstetter, "Reise d. o. F. Novara u. d. Erde," *Geology*, Vol. I (1864), p. 5.

are not a normal phase of shoreline topography, but exist only under properly adjusted conditions. It is apparently essential, first, that the rock from which these benches are carved be homogeneous and moderately resistant to wave erosion, though readily subject to weathering; second, that they be located in sheltered waters, which are provided best by the submergence of maturely eroded areas.

It is difficult to agree with Dana's contention that the surface of shore platforms characteristic of such sheltered waters is governed in its formation and height by "the level of greatest wear," which in his *Manual of Geology*[1] he placed at a little above half-tide mark, though in his earlier detailed account (1849) he showed that with lesser waves it will be below high-water level, while with larger it will be substantially above it.[2] There are reasons for believing that, after mature consideration, Dana[3] was inclined to emphasize wave erosion, rather than control by weathering, in the development of benches such as those of the Old Hat, for he grouped with them others on the exposed coast of New South Wales and elsewhere, which, it may justly be claimed, are distinct in character from the former, and explained all on the basis of his "level of greatest wear."[4] It seems more reasonable, however, to interpret the surface of the platforms as approximately the upper limit of the zone of permanent saturation, below which the rocks are relatively protected from subaerial weathering.

Shortly after the writer had published his 1916 paper, his attention was drawn by Mr. P. G. Morgan, director of the New Zealand Geological Survey,[5] to the fact that Bell and Clarke had previously described prominent shore benches in the Whangaroa (N.Z.) area, and had tentatively explained them in the same manner as he.

[1] J. D. Dana, *op. cit.* (3d. ed.; New York, 1880), p. 676.

[2] According to Ferrar (1925), Dana reverts to this conception in the fourth edition (1895) of his *Manual of Geology*, p. 221.

[3] J. D. Dana, *loc. cit.*

[4] I am greatly indebted to Dr. C. A. Cotton and Mr. P. G. Morgan for a summary of the views expressed by Dana in 1849 in Vol. X (*Geology*) of the "Report of the U.S. Exploring Expedition during the Years 1838 to 1842," which is not obtainable in Auckland.

[5] Personal communication.

Some of the platforms described and illustrated by these authors[1] do not appear, however, to depart materially from "normal" shore profile,[2] but there are others which seem to do so, for they are described as "generally horizontal or nearly so," while the illustrations show that there is an abrupt change of slope at their seaward margins. There is, however, little doubt that many of these Whangaroa shore platforms, more especially those which are said to "rise a little above high water level," are different in origin from those of the Old Hat type in which subaerial weathering plays an important part, for certain of them are ". . . . surmounted by skerries, or pinnacles of harder material . . . . which was not so easily eroded by the waves as the main mass of the shelf."[3] Unless under special circumstances, such residuals are inconsistent with a hypothesis involving " . . . . the co-operation of subaerial weathering, which causes the retreat of the cliffs, with marine transport, which removes the waste so formed."[4] Platforms of this kind demonstrate, on the contrary, the existence, under certain conditions, of a recognizable "level of greatest wear" as conceived by Dana,[5] but it is believed by the present writer that they originate only in exposed situations. The sea-cliffs rising above those which he has examined show signs of vigorous attack by waves and, wherever conditions permit, develop a characteristic overhang. They have a steepness and a general freedom from weathering which contrast strikingly with the lesser slope and more weathered condition of those surmounting benches of the Old Hat type.

Considerations which must be taken into account in evaluating the factors concerned in the development of shore platforms are the nature of the off-shore profile and its relation to waves of different size. When near the time of high water, the relatively small wave of sheltered waters arrives as an unbroken wave of oscillation at the steeply sloping outer edge of a platform of the Old Hat type. Here

[1] J. M. Bell and E. de C. Clarke, "The Geology of the Whangaroa Subdivision," *N.Z. Geol. Surv. Bull. No. 8* (N.S.) (1909), p. 30.

[2] The fact that their inner margins often rise slightly above high-water level is by no means an abnormal characteristic.

[3] J. M. Bell and E. de C. Clarke, *ibid.*, p. 30. [4] *Ibid.*

[5] J. D. Dana, *Rept. U.S. Expl. Exped., 1838–42*, Vol. X, *Geology* (1849), p. 109.

a large portion of it is likely merely to be reflected; another portion, however, will advance over the horizontal shelf as surf, but must dissipate much of its energy before reaching the base of the sea-cliff.

On the other hand, at coasts exposed to great storm waves, conditions are often such that these latter break a long distance off shore and then rise and sweep forward as mighty waves of translation which, at high water, may not break again until they hurl

FIG. 3.—Cut-platform about 2 ft. above mean high water level at North Head, Manukau Harbour, N.Z. The irregularity beneath the prominently overhanging cliff is due to a resistant dyke.

themselves at the sea-cliffs. Their impact is thus, as Dana shows, at a distinct height above high-water level, and, moreover, it is many times more vigorous than that of corresponding oscillatory waves.[1] These storm waves tend thus to develop platforms usually only a few feet in width, which are often slightly above the level of normal high water. Benches of this type have been described from the west coast near Auckland, New Zealand,[2] and, like those of the Old Hat

[1] Johnson (1919), p. 57.

[2] J. A. Bartrum, "The Shore-Platform of the West Coast near Auckland: Its Storm-Wave Origin," *Rept. Aust. Ass. Adv. Sc.*, Vol. XVI (1924), pp. 493–95.

type, have an abrupt descent at their seaward edge, into water which is sometimes several feet deep at low tide. It is suggested that this steep edge results from the attempt of the waves to reproduce normal shore profile under normal conditions, or at lower stages of the tide, when their energy is largely dissipated off shore, owing to the depth of water being less than it is near times of high water.

FIG. 4.—A narrow, though continuous, platform near the "Blowhole," Piha, Auckland west coast, N.Z. A large wave is receding after having been flung back from the cliffs.

These storm-wave platforms appear to be especially characteristic of localities where the coastal rock is resistant: that of the west coast near Auckland is a highly resistant, homogeneous, unjointed volcanic conglomerate. This has been carved into stupendous cliffs which majestically overhang ribbon-like platforms at their base, which appear to be best developed in more exposed situations, though no exact relation between exposure and width of platform could be determined (Figs. 3 and 4). Very probably their height

above the general level of the adjacent shore or off-shore bottom bears a relation to tidal interval, but this has not been established by observation.[1] In contrast with those of the Old Hat type, rock benches of this kind exhibit a very ready response to differences of hardness, or to structural peculiarities such as jointing or bedding, and if the rock medium is not homogeneous, the platform may be highly irregular.

In the recently published *Whangarei-Bay of Islands Bulletin of the New Zealand Geological Survey*, Mr. H. T. Ferrar[2] (1926) discusses shore platforms in some detail. He minimizes the influence of weathering in their production, and considers that the presence of horizontal structures, such as bedding or jointing, is an essential condition. His discussion shows, however, that he misjudges the views of the present writer, for he cites, among other examples, platforms carved from approximately horizontal strata as illustrations of the error of any explanatory hypothesis based on weathering. Shore platforms notched in horizontal rocks, like those of a similar kind in any other situation, generally furnish obvious explanation of their origin in the differences of hardness of adjacent beds. Henderson and Ongley[3] (1923, Plate I), for example, illustrate perfect platforms of this type from Mokau, New Zealand, which could not reasonably be explained by any other process than selective marine erosion of horizontal beds (Fig. 5). Although it was not expressly so stated, the writer's 1916 paper did not aim at discussing all varieties of shore benches, but at explaining how certain of them may develop independent of the structure of the rocks in which they are carved. It is believed that the hypothesis of progressive weathering set forth in that paper (Bartrum, 1916) furnishes the only clue to the origin of a substantial number of shore platforms.

The writer's observations of the jointing of the indurated argil-

[1] The mean tidal range at this part of the coast is approximately 10 ft., while the platforms are about 2 ft. above mean high-water level; the evidence is, however, decidedly against explaining this attitude as a consequence of recent relative uplift of the coast.

[2] H. T. Ferrar, and others, "The Geology of the Whangarei-Bay of Islands Subdivision," *op. cit., No. 27 (N.S., 1925)*.

[3] J. Henderson and M. Ongley, "The Geology of the Mokau Subdivision," *ibid., No. 24* (N.S., 1923).

lites and feldspathic greywackes of mid-Mesozoic age which form the coasts of the areas in New Zealand where the most typical benches of the Old Hat type exist lead him to doubt any substantial regularity of joint systems in those rocks for more than very limited areas. More often than not the joints are haphazard in direction, and commonly are so completely sealed that they are practically invisible until weathering induces a thorough shattering.

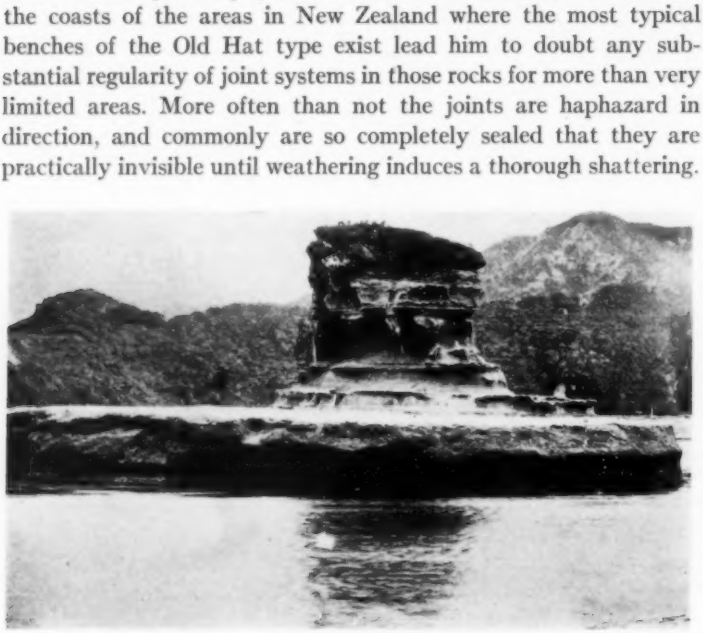

FIG. 5.—Bench carved in horizontal strata, Mokau estuary, N.Z. Reproduced by courtesy of Mr. P. G. Morgan, Director, N.Z. Geological Survey.

It is further important to note that, even if the importance of jointing be conceded for the examples cited by Ferrar (1926), such jointing in itself cannot explain why the platforms are developed at a particular level with respect to high-water mark.

The writer believes that fresh evidence which he has to offer from near Auckland, New Zealand, clearly indicates that such horizontal structures as joints, or bedding planes, are a nonessential factor and that weathering is the controlling influence in the genesis of shore platforms of the Old Hat type. On the west shore of Hobson Bay, a shallow southern arm of Waitemata Harbor, a thick bed of the fine-grained compact phase of the volcanic tuff locally called the "Parnell grit" forms the shoreline for nearly 100

yards at a place a short distance south of a railway embankment now under construction. This bed dips toward the sea-cliffs at an angle of about 30° in a south-south-west direction; bedding planes are poorly shown, and, in the unweathered state, the rock shows but a few wide-spaced, irregular joints. A very flat, smooth, horizontal platform with a maximum width of 65 feet and a length of 80 yards has been developed from this bed; its surface is scarcely covered at high water, and its outer edge drops steeply away for about 2 feet in

FIG. 6. Bench of "Old Hat" type, Hobson Bay, Auckland, N.Z.

vertical distance to the general shore level, as is illustrated by Figure 6. A band of fine-grained sandstone about 2 feet in depth and composed of moderately well-cemented grains of quartz, feldspar, and other materials immediately underlies the tuff, and, though more resistant than other accompanying sandstones, has been removed by wave erosion from the greater part of the seaward edge of the platform. At its southern end, however, the last 15 yards of its outcrop has not been reduced by the waves to conform with the very gently sloping "normal" shore profile off shore of it, for rapid shallowing of water near high-tide mark has reduced the efficiency of the waves. The band of sandstone therefore forms a narrow homoclinal ridge which rises to an average height of a little less than 2 feet above the general level of the adjacent platform, and of 1 foot or 18 inches above normal high-water level. Its dip slope is exposed

in a narrow channel excavated in the tuff by the waters of receding waves, as is illustrated in Figure 7.

A fact of great importance is that, if this gutter be excepted, the rock bench is as perfectly developed behind the sandstone barrier as at any other part of its extent, and that, with the exception of a small bay near the outer end of this barrier, its outer margin has not receded very materially from the line of outcrop of the upper bedding surface of the sandstone, a fact which can reasonably be taken to

FIG. 7.—Bar of hard sandstone rising above high water level and protecting the south end of the platform shown in Figure 6, which is continued beyond the concrete wall.

indicate that the resistance to wave erosion offered by the tuff underlying the platform is not greatly different from that offered by the sandstone. Its state of consolidation appears, indeed, to be decidedly superior to that of the latter.

Consideration of the facts disclosed raises several questions:

1. If the platform is due primarily to the existence of a "level of greatest wear," should not similar shelves have been cut in the sandstones which outcrop continuously in sea-cliffs near by? Such platforms are non-existent.

2. If wave erosion is the dominant factor in its development, why is the platform carved at the same level as elsewhere behind the miniature peninsula of sandstone which strikes almost parallel

to the shoreline at this locality and so provides admirable shelter in its lee?

3. Do differences of material of the tuff and of the adjacent sandstones explain the anomalies raised by the two preceding questions?

The answer to this last question is that there are pronounced differences in the physical characteristics of the two sets of beds, and that these undoubtedly furnish an eminently reasonable solution of the problem. The sandstones of the locality disintegrate relatively slowly under exposure to subaerial weathering agencies, but, in contrast with them, the volcanic tuff, when exposed in the cliff-faces, shrinks so considerably as a result of drying that it disintegrates readily into small fragments which are easily removed from the base of the cliffs even by weak waves.

Throughout a zone which has its upper surface slightly below high-water level, however, the same rock remains permanently wet, and disintegration is not called into play as in the upper zone. It is, therefore, relatively so resistant that the weak waves which break and rebreak on the gently sloping shore seaward of it have not been able to cut it back as rapidly as weathering has caused the retreat of the cliffs, and in this way the platform has come into existence. Original jointing can have had little or no influence, because, as already remarked, the tuff is singularly free from any but wide-spaced irregular joints.

If this hypothesis be followed to a logical conclusion, it is evident (assuming its correctness) that there must be a natural limit to the width of a bench of this type. As the width increases, the waves arriving at the base of the sea-cliffs must become correspondingly enfeebled, owing to the greater distance that they have to travel after receiving a severe check at the edge of the platform. They will thus be less effective in removing the products of weathering from the base of the cliffs, and, in this manner, a natural balance will be attained, since the retreat of the cliffs can continue only so long as wave transport suffices to prevent the accumulation of a beach at their base.

In conclusion, it has been shown that a certain broad horizontal shore platform typified by the Old Hat at the Bay of Islands may de-

velop in sheltered waters quite independent of rock structure (Fig. 8). It originates primarily as a consequence of progressive weathering of the sea-cliffs down to the level of the platform, which is slightly below that of normal high water. There is also another type of "abnormal" shore platform that is not dependent upon rock structure

FIG. 8.—Platform of the "Old Hat" type. About 11 miles south of Waikato River on west coast of North Island, New Zealand. Lower platform is normal cut platform. The upper platform is a bench of the "Old Hat" type in which weathering has been the main factor in development. (Photo by O. Kemp.)

for its existence; this is a narrow bench at the base of steep sea-cliffs at a height which approximates normal high-water level but may be a foot or two above it. It is developed only in relatively exposed situations. Its carving is ascribed to vigorous storm-waves, which have their maximum efficiency as erosive agents near times of high water. It is urged that these platforms be regarded, not as abnormal developments of a retrograded shoreline, but as the expectable and by no means uncommon products of wave erosion under conditions which have been traced in the foregoing pages.

THE EXISTENCE OF A ONCE HOMOGENEOUS MAGMA-MASS UNDERLYING CENTRAL AMERICA

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ABSTRACT

A zone 1,000 km. long, of what is now the Pacific Coast of Central America, has probably been the scene of volcanic activity at intervals since the Cretaceous. The lava types extruded during and since the Pleistocene are: basalt; an intermediate type; latite; dacite; rhyolite. The two most important volumetrically are the intermediate type, "andelatite," and the dacite in the form of pumice. Each shows remarkable homogeneity, both mineralogical and chemical, over a distance of 730 km.

All the lavas have apparently been derived from a common magma by differentiation under uniform conditions; the horizontal cross-section of the ancestral magma-mass was of the order of 1,000 by 75 km.

Active volcanoes, even only a few kilometers apart, are quite independent of one another, and the source of energy in each case would appear to be local.

PREVIOUS WORK

Although a great many observations of a general character have been reported, especially concerning the volcanoes, comparatively little geological work has been accomplished in Central America, save in isolated areas. A bibliography[1] has been compiled, of about six hundred titles, covering the period 1529–1925, which is thought to be fairly complete. Vaughan has summarized the geology of Central America; Hershey, Hill, MacDonald, and others have described the geology of the Canal Zone and parts of Panamá; Pittier, Romanes, and Gabb have written on Costa Rica; Hayes, Crawford, and many others on Nicaragua; Powers, Bacon, and others on Honduras; Fleury and Dollfus and Montserrat on El Salvador; Powers, Karston, and others on Guatemala and parts of British Honduras; Vicquez, Van de Putte, and Montessus de Ballore have summarized the seismic and volcanic records of Costa Rica, Guatemala, and Central America, respectively; and Sapper has written voluminously on the physical geography of the entire region, and

[1] Vol. II. Thesis.

has made a very useful summary of all that is known concerning the volcanoes. Dr. Lindgren and Professor Jones suggested that a reconnaissance among the volcanoes might prove profitable, and it was accordingly made, in the spring of 1921. This is a brief résumé, principally petrologic, of the revised report[1] made upon it.

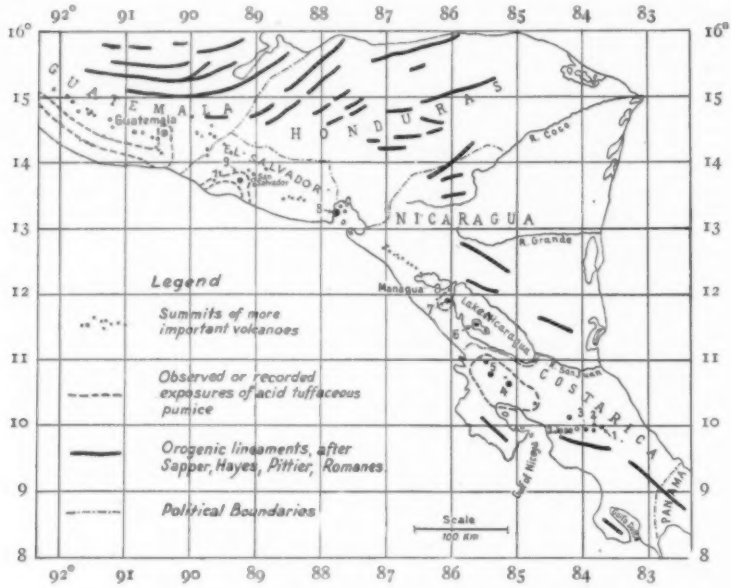

FIG. 1.—Outline map of Central America showing the more important volcanoes. Partial analyses were made on material from the nine numbered volcanoes: (1) Turrialba, (2) Irazú, (3) Poás, (4) Miravalles, (5) Rincon de la Vieja, (6) Ometepe, (7) Masaya, (8) Conchagua, (9) San Salvador. For other volcanoes see Table I, p. 810.

TECTONICS

Central American structure[2] is apparently very old. Its inception was possibly in the pre-Cambrian; it was developed in the Upper Paleozoic, further emphasized during the Tertiary, and possibly also during the Recent. It is worthy of note that the structural lines

[1] Unpublished thesis, 1924. Library of Department of Geology, Massachusetts Institute of Technology, Cambridge, Mass. 2 vols.

[2] For the lineaments, see map (Fig. 1).

nearly all have roughly the same trend, namely, E.–W., athwart the strike of the Pacific Cordilleras of North and South America. The structure is thus Antillean, and not Cordilleran, in affinities.

The line of great volcanoes cuts across the trend of these lineaments, striking roughly NNW.–SSE. It is thus parallel to no range now visible in Central America, with the exception of the closely folded and nearly drowned vestiges of lineaments in Nicoya and the Golfo Dulce.

DISTRIBUTION OF VOLCANOES

The volcanoes stud the Pacific shores of Central America. Between Tacaná in the north and Turrialba in the south, a distance of 1,071 kilometers, one finds just one hundred volcanoes,[1] the heights ranging from 500 to 4,140 meters.

Viewing them as a unit, they may be said to form an arcuate range, concave toward the Pacific—not, however, concave toward the "deep," for the 1,000-fathom line lies roughly 250 kilometers out to sea. The range is made up of many small segments up to 200 kilometers in length, some of which are convex toward the Pacific and some of which show no lineal arrangement. Toward the south, the lineal arrangement of the segments is pronounced. Toward the north, the crust failed, not along one break, but in many irregular fractures, and the belt of volcanism becomes about 100 kilometers wide.

HISTORICAL VOLCANOLOGY

The region was the scene of volcanism in the Eocene, and possibly in the uppermost Cretaceous. Activity languished during Oligocene folding and intrusion, to culminate in a display of explosive fury during the troubled times of Miocene uplift. The volcanic basements of the present volcanoes are quite possibly Pliocene in age, while the cones themselves probably range from the early Pleistocene to the last decade of the eighteenth century.

TYPES OF ACTIVITY

In general, the cones may be said to be built of *ejectamenta*, resting upon a basement of flows, while occasional flows have

[1] For the names and position of the more important ones, see Fig. 1 and Table I.

breached the weak walls of the cones in recent times.[1] The activity has been largely explosive.[2] This explosive activity has often caused

TABLE I*

THE MORE IMPORTANT VOLCANOES OF CENTRAL AMERICA

Name	Present State	Last Eruption	Height in Meters	N. Lat.	W. Long. Greenwich
Costa Rica:					
Turrialba	Quiescent	.....	3,820	10° 01′	83° 47′
Irazú	Active-quiescent	1726	3,440	9 59	83 52
Barba	Dormant	.....	.....	.....	.....
Poás	Quiescent	.....	2,690	10 07	83 93
Miravalles	Dormant	.....	1,680	10 41	85 10
Rincon de la Vieja	Active-quiescent	.....	1,920	10 50	85 22
Orosí	Dormant	.....	2,640	10 59	85 29
Nicaragua:					
Madeira	Dormant	.....	1,530	11 27	85 31
Ometepe	Active	1921	1,560	11 33	85 37
Masaya	Active	1858	900	11 59	86 11
Momotombo	Active	1852	2,140	12 25	86 33
Rota	Quiescent	.....	797	12 33	86 46
Telica	Active	1850	1,160	12 36	86 51
El Viejo	Quiescent	.....	1,740	12 42	87 01
Cosegüina	Dormant	1835	1,100	12 58	87 55
El Salvador:					
Conchagua	Dormant	.....	1,200	13 16	87 50
Llopango	Active	.....	1,040	13 40	89 03
San Salvador	Quiescent	1917	1,880	13 44	89 16
Izalco	Active	Constant	1,830	13 49	89 38
Guatemala:					
Pacaya	Quiescent	1775	2,560	14 22	90 36
Agua	Dormant	.....	3,790	14 27	90 45
Fuego	Quiescent	1880	3,690	14 28	90 53
Acatenango	Quiescent	.....	4,140	14 30	90 53
Atitlán	Quiescent	1852	3,000	14 35	91 11
Tacaná	Quiescent	1855	3,500	15 07	92 06′

* Taken from Sapper, *Die Mittelamerikanischen Vulkane*, and Russel, *The Volcanoes of North America;* modified by personal observation. Sapper lists one hundred volcanoes. Those in italics were visited by the author.

the truncation of the cone, showering the surrounding countryside with a mantle of débris.[3] At the moment, they are mostly quiescent,

[1] San Salvador, in 1917.

[2] Masaya, the famous Nicaraguan volcano, apparently supported a lava lake of the Kilauea type during the sixteenth century. Oviedo (*Hist. General de las Indias*, Vol. XLII [Madrid, *ca.* 1510–30; ed. Ternaux], quoted by Humboldt, *Cosmos*, Vol. V, p. 259) says that some priests, having obtained from Charles V a concession to extract the "molten gold and silver" (*sic*) from the volcano, sold stock in the venture to the good people of Nicaragua, and then decamped with the funds, thus transacting the first recorded American mining promotion!

[3] For instance, Cosegüina, in 1835, the most violent explosion known to man up to that time.

or in a mature solfataric state, although seismic disturbances are nearly continuous. The active ones visited, notably Ometepe in the Lake of Nicaragua, Rincon de la Vieja in the Guanacaste region of Costa Rica, and Irazú (Figs. 2 and 3), near the city of Cartago in the same country, are giving off principally steam, with explosive violence. By test this steam is respirable, and the senses could detect no other constituents.

FIG. 2.—Irazú, looking northwest. The vapors are respirable

Although a series of as many as ten major volcanoes may be located on a straight line, so close together that their lower flanks are held in common, yet the activity of a given volcano may be quite independent of the state of its neighbors. This is not only true at the moment, but an inspection of the records[1] shows it to have

[1] Montessus de Ballore, *Tremblements de terre et éruptions volcaniques au Centre-Amérique depuis la conquête espagnole jusqu'à nos jours* (Dijon, 1888); "Les tremblements de terre": Vol. I, *La Géographie Seismologique* (1906); Vol. II, *La Science Seismologique* (1907); Vol. III, *La Géologie Seismologique* (1924).

C. G. Vicquez, *Temblores, terremotos, inundaciones y erupciones volcánicas en Costa Rica, 1908–1910* (San José, Costa Rica, 1910) (reviewed in *Seis. Soc. Amer. B.*, Vol. I, p. 23).

Van de Putte, "Phénomènes seismiques et volcaniques en Guatemala," *La Nature* (52e année, 1924). Summarizes data from 1561 to 1917.

been frequently true since the sixteenth century for the several hundred reliable reports of activity. This independence is also true of the lavas extruded. The activity of Turrialba (Fig. 4) in 1865 produced a basalt; that of Conchagua in the Recent an olivine basalt; that of Cosegüina (Conchagua's immediate neighbor) in 1835 a rhyolite (or dacite?); that of San Salvador in 1917 a latite;

FIG. 3.—Irazú, looking north from the highest point of the crater rim. In the lower oreground, its edge marked by a band of white, is the floor of the oldest visible crater. Below this, 300 or 400 m., is seen the confused throat of the present activity, nearly choked with lapilli, but containing three open chimneys, and two completely clogged up.

while activity of the vents in the Guanacaste laid down a thick carpet of very fine dacite pumice prior to the uplift of the Guanacaste above sea-level (Pleistocene, Recent?); and many of the vents from time to time have given off large quantities of the lava intermediate between an andesite and a latite, which is characteristic of this region.

PETROGRAPHY AND PARTIAL ANALYSES

The literature on the petrography of the lavas of Central America is scanty. It is to be found under "Petrography" in the

Index to the Bibliography, Volume II.[1] With the exception of Panama and the Canal Zone, there is a nearly complete lack of petrographical descriptions, and only six analyses, which Washington calls "fair," are available.

FIG. 4.—The westernmost crater of Turrialba, from the summit, looking west. The small crater is about 250 m. in diameter.

In this collection, there are six types to consider:

1. A potassic olivine-basalt, the extrusive equivalent of a melasyenogabbro (analysis 1)
2. An alkali basalt, the extrusive equivalent of a melasyenodiorite (analysis 2)
3. A type, occurring in large quantities, intermediate between an andesite and a latite; the extrusive equivalent of a monzodiorite (analyses 3–8, inclusive)
4. A hypersthene-latite (analysis 9)
5. A biotite-hornblende-dacite (analyses 10, 11)
6. A biotite-hornblende-rhyolite (analyses 12)

These naturally fall into two groups: the acid pumices (Nos. 5 and 6) and the intermediate to basic lavas. The latter will be described first.

In all, about five hundred specimens of types 1, 2, 3, and 4 were

[1] Of the thesis.

collected. They differed considerably in physical appearance from place to place, were deceiving in the field, and not readily distinguishable the one from the other. They varied from black to gray, phyric to aphyric, dense to highly vesicular. They often showed marked flow structure. "Andesitic" weathering is characteristic, completely leaching the lava, and rendering it white, compact, and friable.

It is impossible to gauge the relative ages of the specimens studied, but that the ages are varied is certain, based upon considerations of stratigraphy, physiography, paleontology, the degree of weathering, and the position on the cone from which the specimen was taken. Some specimens (latite) are certainly as recent as 1917;[1] some (basaltic) probably as old as the late Pleistocene,[2] or earlier.

No indications of any definite sequence were noted.

Microscopically, the four basic types show close relationships, merging imperceptibly into one another. By far the most important is No. 3. Of the 225 slides studied, those from Irazú, Poás, Miravalles, Rincon de la Vieja, Ometepe, and Masaya, a total of 175, all proved to belong to this type. Not only was it impossible to tell one slide from another within a given one of these suites, but even at the close of the optical work it was not possible to distinguish the slides of one of these volcanoes from those of another.

The essential phenocrysts are labradorite, augite, and hypersthene, with less of olivine. Magnetite is a major, and apatite a minor accessory. Orthoclase is present, principally in the groundmass.

The plagioclase, while usually labradorite, has an extreme range, apart from zonal growths, of from Ab_{30}–An_{70} to Ab_{50}–An_{50}. A zonal intergrowth between hypersthene and augite is characteristic, in which the hypersthene is the core. The zoning may or may not be parallel to the *C*-axis of either mineral. The augite is practically colorless and non-pleochroic. The hypersthene shows more color,

[1] The flow of San Salvador, April, 1917.

[2] Based upon a determination by Dr. Mathews (personal statement) of certain mammalian forms as being undoubtedly Pleistocene, but of unknown species. They were associated with bowlder beds containing much volcanic detritus from near Aguas Calientes, Costa Rica. The volcanic detritus presumably emanated from Irazú or Poás, or both. Material secured through the courtesy of Señor Don Fidél Tristán.

a feeble pleochroism, and may grade toward enstatite. The olivine is in some cases (+) and in others (−). It shows heavy resorption rims, and, although the analyses leave little room for such a variation, the quantity of olivine in the slides is very variable. (The lavas at Conchagua were probably quenched, and these slides show the most olivine.) It would seem as though the olivine, in part at least, might very possibly be under the control of the Bowen-Anderson[1] effect.

The ground-mass is usually trachytic, often with a glassy base. Some of it is apparently birefringent, with low refractive index, and is presumably orthoclase. The fluidal structure is not pronounced.

These basic differentiates are apparently rather rich in iron, attested to by the abundance of magnetite in the ground-mass, by the optical constants of the olivine, indicating a high FeO content, and by the extremely low viscosity of the infrequent flows, the laminae being often but 1 millimeter in thickness.[2]

The lavas from Turrialba (analysis 2, basalt) and from Conchagua (analysis 1, olivine-basalt) differ from this intermediate type only in a tendency for the Ab–An ratio to approach bytownite, for the hypersthene and augite to be somewhat more abundant, and for the ground-mass to take on a basaltic texture. Whether the rather irregular increase in the amount of olivine in these basic members is likewise due in part to the Bowen-Anderson effect, it is difficult to say. On the other hand, the lavas from the flow of 1917 from the volcano San Salvador (analysis 9, latite) show a slight tendency toward a more acid feldspar than the average for the intermediate type; the shreds of augite have disappeared from the ground-mass; orthoclase is somewhat more abundant; and phenocrysts of both hypersthene and augite are less conspicuous.

[1] N. L. Bowen, "The Tertiary System: Diopside, Forsterite-Silica," *A.J.S.*, Vol. XXXVIII (1914), pp. 207–64; Bowen and Anderson, *ibid.*, Vol. XXXVII (1914), p. 487; O. Anderson, "The System: Anorthite-Forsterite-Silica," *ibid.*, Vol. XXXIX (1915), pp. 407–52.

[2] For a discussion of fluidity of slags as a criterion of the Fe content, see J. H. Whiteley and A. F. Hallimond, *Jour. Iron and Steel Inst.*, Vol. XCIX (1919), p. 199, and J. H. Whiteley, *ibid.*, Vol. CI (1920), p. 308, quoted by H. S. Washington; and of high iron content as a cause of fluidity in lavas, see H. S. Washington, "Deccan Traps and Other Plateau Basalts," *Geol. Soc. Amer. Bull.*, Vol. XXXIII (1922), pp. 765–804; also *Carnegie Geophys. Lab. Paper 470.*

PARTIAL ANALYSES

It is regrettable that full analyses are not available. The partial analyses (Table II) have proved instructive, however, especially when one notes how accurately small variations in the optical constants have been mirrored in the chemical proportions. The unusual homogeneity of the lavas of Irazú, Poás (Fig. 5), Miravalles, Rincon de la Vieja, Ometepe, and Masaya, as noted with the microscope, is

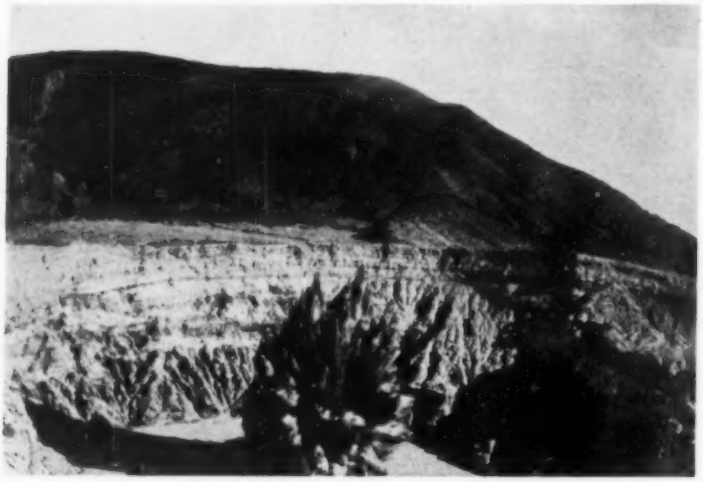

FIG. 5.—A geyser-like explosion of mud and steam in the sulphurous lake at the summit of Poás. The lake lies 400 m. below the crater rim. (Photo by F. Tristán.)

confirmed by analyses 3, 4, 5, 6, 7, and 8. The average for these analyses is given in Table III.

If we define[1] a latite as an effusive rock in which the ferromagnesian minerals constitute from 5 to 50 per cent of the whole, and in which orthoclase constitutes from about 60 to about 40 per cent of the total feldspar, and if we define an andesite as an effusive rock in which the proportion of femics is the same, but in which the orthoclase constitutes less than 5 per cent of the total feldspar, it will be seen that this lava type falls nearly exactly midway the two, the

[1] A. Johannsen, *Essentials for the Microscopical Determination of Rock-forming Minerals and Rocks* (University of Chicago Press, 1922), p. 44.

TABLE II

PARTIAL ANALYSES OF CENTRAL AMERICAN LAVAS

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
SiO_2	46.76	51.55	53.53	55.00	55.36	55.18	55.49	55.62	57.89	67.53	67.06	70.93
CaO	9.71	9.91	8.31	7.96	7.18	8.30	7.67	8.29	5.68	2.13	3.41	1.14
Na_2	2.21	2.53	3.24	2.58	3.39	2.55	2.78	4.10	3.74	2.26	4.71	4.29
K_2O	1.98	2.39	2.11	4.41	2.46	3.03	2.10	2.93	3.66	4.47	2.09	4.21
Or	20	20	17	31	15	26	19	18	23	.....	.....	.....

I. Olivine-basalt: Conchagua—specimen 262: from flow on NE. flanks where it entered Gulf of Fonseca. Specimen taken from below low-tide mark, and thought to have been quenched.

II. Basalt: Turrialba—specimen 71: surface of S. margin of crater lip.

III. Andelatite: Masaya—specimen 253: collected by Indian Felipe Guevarra; from cut in railroad 10 km. S. of Granada and presumed to have emanated from Mesaya. The cut was observed from the train.

IV. Andelatite: Irazú—specimen 36: side of spring at 2,924 m., at side of trail on SW. flanks.

V. Andelatite: Poás—specimen 15: S. flank near roadside, not far from Alajuela.

VI. Andelatite: Miravalles—specimen 124: at 740 m., 0.5 km. S. of solfataras, at foot of Miravalles.

VII. Andelatite: Rincon de la Vieja—specimen 155: hill of fragments 3 km. S. of Rincon de la Vieja.

VIII. Andelatite: Ometepe—specimen 168: common type, found as fragments with wide distribution about lower reaches of Ometepe.

IX. Hypersthene-latite: San Salvador—specimen 258: right of way of railroad, 10 km. NW. of city of San Salvador, from midst of breach flow of 1917, over which temporary tracks were laid. Flow had moved slowly across wet ground, was perhaps 10 m. thick, of extreme aa texture.

X. Dacite: Costa Rica—specimen 126: from streets of Bagaces, in Guanacaste. Bagaces is built of this material.

XI. Biotite-hornblende-dacite: El Salvador—specimen 25: from near right-of-way at Apopla, El Salvador. It is continuous from San Salvador to beyond here, bedded, and at least 30 to 50 m. thick.

XII. Biotite-hornblende-rhyolite: Guatemala—specimen 267: from Mazatanango. Little else seen from San José to Guatemala City, which stands at 910 m.

TABLE III

AVERAGE OF SIX PARTIAL ANALYSES OF A CENTRAL AMERICAN LAVA "ANDELATITE"

SiO_2	55.38
CaO	8.28
Na_2O	3.11
K_2O	2.84
Or	21

orthoclase content being about 20 per cent. It is thus an andelatite,[1] the effusive equivalent of Johannsen's[2] monzodiorite.

In attempting further to characterize this type, so important volumetrically, it might be noted that the lime content is rather high, and that the potash shows unusual persistence in the basic members.

THE ACID PUMICES

The acid pumices (analyses 10, 11, 12) are very widespread,[3] and of considerable development. They are well exposed in the Guanacaste region of Costa Rica; in many horizons intercalated with the lavas on the Island of Ometepe, in the Lake of Nicaragua; at Masaya, in Nicaragua; from Acajutla toward San Salvador, capital of El Salvador; from San José de Guatemala to Guatemala City; and finally, near Tapachula, in Chiapas, Mexico.

In many places they are well bedded, and in the Guanacaste the beds are thin, and bear sun-cracks on their upper surfaces.

Their time relationships with the more basic lavas are in doubt. In the exposed throat of Turrialba, in Costa Rica, and in a certain well on the Island of Ometepe in the Lake of Nicaragua, at the base of the active volcano Ometepe, layers of pumicious *ejectamenta* occur to depths of 250 and 50 meters, respectively, and the entire plain of the Guanacaste region in Costa Rica was apparently subjected to showers of fine, pumicious sand before its emergence above sea-level (late Pleistocene?—Recent?), while in the catastrophic activity of Cosegüina in 1835, an apparently similar pumice was ejected in enormous quantities. It cannot, therefore, be said that a definite time relationship exists between the two types.

In the hand specimens, the pumicious character is apparent. The rock appears white, or nearly so, is light and extremely friable. Small subhedra of quartz are visible, but the distinguishing mineral is a brown-black biotite fairly evenly disseminated in small cleavage flakes. Glassy centers are common. They are generally drawn out

[1] A. Johannsen, "A Quantitative Mineralogical Classification of Igneous Rocks," *Jour. Geol.*, Vol. XXVIII (1920), p. 174.

[2] *Essentials for the Microscopical Determination of Rock-forming Minerals and Rocks*, p. 44.

[3] See map (Fig. 1).

into fibrous sheaves of silky luster, frequently lending a tuffaceous character to the rock. The hand specimens from Guatemala cannot be distinguished from those of the Guanacaste.

The thin sections of this type were few in number, and some turned out badly. Biotite, hornblende, and magnetite, all distinctly but not seriously altered, together with some plagioclase, probably

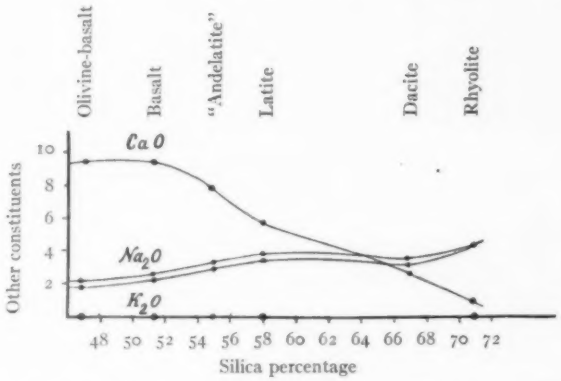

FIG. 6.—Variation diagram of the young volcanic rocks of Central America

near Ab_{70}–An_{30}, make up the phenocrysts and subhedra. Quartz is present.

The ground-mass is rather fine, and contains spherulites; some glass, partially devitrified; and usually considerable comminuted plagioclase. Orthoclase (sanidine?) is probably present, but was not positively identified.

GENETIC RELATIONS

The most convenient way in which to bring out the relationships between all these various lava types is by means of the variation diagram (Fig. 6). To avoid confusion, analyses 3, 4, 5, 6, 7, and 8 have been averaged to form the type analysis of this member, and analyses 10 and 11 have been averaged to give the dacite.

It is, perhaps, a bit dangerous to draw conclusions from a variation diagram based upon partial analyses, yet the unmistakable

similarity between these curves and the type curves figured by Holmes,[1] the close sympathy between the soda and the potash, their nearly linear variation with respect to silica, the tendency of the K_2O to increase relatively to Na_2O as differentiation proceeds, together with the position of the lime-alkali crossing, would seem to support the optical evidence in suggesting that all these lava types are genetically related, and represent progressive differentiation from a simple magma, common to the entire region. This is all the more remarkable when we remember that the analyses were made upon random specimens, chosen, it is true, as typical of that volcano, but, nevertheless, representing only an infinitesimal portion of the

TABLE IV

SILICA CONTENT OF LAVAS

Circum-Pacific	SiO_2
Andes	60.86
Mexico and Central America	59.66
California	62.43
Alaska	63.43
Kamchatka	63.27
Japan	61.55
New Zealand	58.25
Intro-Pacific:	
Pacific islands	50.06

whole, and separated from one another by many tens of kilometers; in the case of the acid pumices, indeed, analyses 10, 11, and 12 are separated from one another by about 300 kilometers.

Washington and Clarke[2] have attempted to indicate in a general way the differences between the generally uniform Circum-Pacific and the more heterogeneous Intro-Pacific lavas. They have calculated regional averages based upon the 5,159 superior analyses reported by Washington, showing, for instance, the silica content of the lavas from different regions (Table IV).

Although no quantitative volumetric measurements are possible, it is perhaps justifiable to recalculate the percentage for Central America in the light of these new data. Taking the average of

[1] A. Holmes, *Petrographic Methods and Calculations* (London, 1921), pp. 440–57.

[2] *U.S.G.S. Prof. Paper 127.*

analyses 3–8, inclusive, for the characteristic intermediate type, the average of analyses 10, 11, and 12 for the acid types, and the other single analyses at full value, and weighting them according to one's impression in the field, we obtain the proportions of Table V.

TABLE V

VOLUME DISTRIBUTION OF YOUNG CENTRAL AMERICAN LAVAS

	Percentage
Olivine basalt	5
Basalt	5
Andelatite	30
Latite	10
Acid types	50
	100

Applying these ratios to the partial analyses, we obtain the average partial analysis of Table VI. It will be noted that, although the approximation is assuredly crude, yet the silica is fairly close to Washington's average for Mexico and Central America, and this region definitely conforms to the acidic Circum-Pacific system in contrast to the more basic Intro-Pacific types.

TABLE VI

AVERAGE PARTIAL ANALYSIS OF YOUNG LAVAS FROM CENTRAL AMERICA

SiO_2	62
CaO	5
Na_2O	3
K_2O	3

SUMMARY AND CONCLUSIONS

Summing up the petrological evidence, we find that in a zone about 700 kilometers long and from 20 to 75 kilometers wide, a half-dozen lava types have been recognized; that the horizontal distribution of the various types is not restricted, but that, on the contrary, the two most important types are found abundantly over the whole length of 700 kilometers, and that specimens of a given type from one end of the region are practically or wholly indistin-

guishable from specimens of that type coming from 700 kilometers away; that a variation diagram based upon a dozen partial but trustworthy analyses suggests that all these types may be interpreted as differentiation products of a common ancestral magma. One would conclude from this that the probability that those various types, and more especially the various outcrops of the same types, are the result of fortuitous parallel development from many small and independent magma-masses is considerably less than the probability that all these rocks were derived from a common ancestral magma-mass underlying the whole region,[1] and now congealed.

On the other hand, the sum of the volcanological evidence (not treated in detail in this paper) lends strong support to Dr. Day's theories[2] concerning the local nature of thermal phenomena. Not only are the volcanoes quite independent of their immediate neighbors, but their products bear no recognized systematic interrelationship. One volcano may be belching forth showers of acid lapilli at the same moment that a near neighbor on one side is indulging in a gentle basic flow, while an equally near neighbor on another side is at that moment ceasing its activity.

If we accept these two suppositions, i.e., the continuity and original homogeneity of the magma-mass underlying Central America, and the local character of the thermal phenomena during the past three hundred years, we are led to complete our supposititious picture as follows.

[1] The lavas of the Japanese arcs are also said to be unusually homogeneous, and are apparently of the same general type (see, for instance, H. S. Washington, "The Chemistry of the Pacific Volcanoes. The Limitations of Our Knowledge," *Spec. Pub., Bernice P. Bishop Museum*, Vol. VII [1921], pp. 325–45; same in *Carnegie Geophys. Lab. Paper 443*).

[2] A. L. Day, "Possible Causes of Volcanic Activity at Lassen Peak," *Jour. Franklin Inst.*, Vol. CXCIV (1922), pp. 569–82; same in *Carnegie Geophys. Lab. Paper 465*. "Some Causes of Volcanic Activity," *Jour. Franklin Inst.*, Vol. CC (1925), pp. 161–82. His conclusion, based upon observations at Kilauea and Lassen, together with laboratory work, is that gases in solution in the magma are the causes of activity, being discharged upon solidification. If the gas is mainly H_2O, we have relatively cold-steam explosions (Lassen). If the gases include H_2, Cl_2, S, hydrocarbons, etc., their reactions cause higher temperatures, and lava flows of the character well known at Vesuvius, Stromboli, or Kilauea occur; but, in any case, the molten material is purely local, and limited to the pocket where it is being formed. It is not part of a general subterranean supply.

We must assume that the local pockets of fusion which underlie the volcanoes are casually spaced—some near the surface, others perhaps at considerable depth—and that they are stoping material from different levels in the congealed mass. Thus two neighboring volcanoes might be both tapping a basaltic horizon, whereas 500 kilometers away one volcano is tapping the same horizon, while neighbors are tapping acid and intermediate horizons. The *ejectamenta* of the first three will be indistinguishable from one another, but those of all five will lie on a smooth curve in a variation diagram.

SUBMARINE PILLOW LAVAS OF SOUTHEASTERN ALASKA[1]

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ABSTRACT

Pillow lavas are of widespread occurrence in the formations of the Lower and Middle Ordovician, Middle and Upper Devonian, Permian, Upper Triassic, and to a minor extent of the Upper Silurian in Southeastern Alaska. Evidence is given to show that they all originated under submarine conditions. Tertiary volcanics are present in large volume, but were formed under subaerial conditions and show practically no pillow lavas. These data all support the hypothesis that pillow lavas, where developed in quantity over a wide area, are of subaqueous origin.

Extreme diversity of opinion exists among geologists as to the origin of pillow or ellipsoidal lavas, and their significance as to conditions of subaqueous or subaerial origin. For example, Collins and Quirke[2] write:

> Exponents of a submarine origin of iron formations have stressed the association of the iron formation with ellipsoidal greenstones and the opinion that an ellipsoidal structure is due to subaqueous deposition. It has been never adequately established, however, that submarine or even aqueous conditions are necessary for the development of an ellipsoidal structure in lavas, and certainly there is little evidence to be found in Michipicoten district to support the theory.

Martin,[3] in a similar strain, writes as follows concerning pillow lavas of the Kenai Peninsula and Kodiak Island in Alaska:

> These volcanic deposits, so far as known, are not intercalated with marine sediments and presumably were poured out on land during the Permian or early

[1] Published by permission of the director of the U.S. Geological Survey.

The writer is indebted to Drs. Dall, Kirk, Girty, Hollick, Stanton, and Ruedemann for the identification of fossils upon which is based the age of the formations discussed.

[2] W. H. Collins and T. T. Quirke, "Michipicoten Iron Ranges," *Can. Geol. Surv. Mem. 147* (1926), pp. 74.

[3] George C. Martin, "The Mesozoic Stratigraphy of Alaska," *U.S. Geol. Surv. Bull. 776* (1926), p. 129.

Triassic period of emergence. The nonfossiliferous sedimentary rocks of the Orca group that are intercalated with the greenstone are, in the writer's opinion, not marine.

On the other hand, Wells[1] writes: "In view of the evidence brought forward by Lewis, one would be bold to deny the possibility of something akin to pillow structure being found in subaerial flows, but the geological record contains few, if any, known examples of such."

The writer presents here evidence from Southeastern Alaska which he believes strongly supports the hypothesis that pillow lavas developed in quantity over a wide area are of subaqueous origin.

Ordovician volcanics are well exposed at the south end of El Capitan Passage, and consist of a thick series (3,000 ft. or so) of andesitic lavas (in part with pillow structure), andesite porphyry conglomerates (only slightly waterworn), andesitic breccias, and some graywacke with interbedded slate. Graptolites are found in slate layers in graywacke beds which are intercalated in the lower part of the formation and associated with pillow lavas. At one locality, andesite pillows several feet in diameter have a rim or interstitial pockets of a hornfels or cherty material; and the flow, of which they form the lower portion, directly overlies graptolitic black slates. Fossiliferous slate and graywacke beds are also interbedded with volcanic breccias.

Pillow lavas are present but not common in the Silurian formations. Where found, they occur locally intercalated in fossiliferous marine limestone.

In the Middle Devonian formations pillow lavas are abundant, and occur between or within formations carrying marine fossils. Limestone occurs locally as interstitial pockets between the pillows, and as lenses between the flows. There are several thousand feet of the volcanic formation, but breccias, tuffs, and sediments make up part of this thickness. In part the volcanics consist of interbedded pillow lavas and a peculiar limestone-andesite rock. The latter is in part a volcanic breccia with a limestone matrix and in part a con-

[1] A. K. Wells, "The Problems of the Spilites," *Geological Magazine*, Vol. LX (1923), p. 65.

glomerate of andesite and limestone in a limestone or andesitic matrix.

On the north end of Kupreanof Island, an Upper or Middle Devonian formation consists of very thin-bedded tuffs with sparing chert layers; thick-bedded tuffs with interbedded calcareous tuffs or tuffaceous limestones; and in minor amount flows of pillow lava, banded chert beds, and slate. The tuffs carry marine fossils.

In the lower division of the Permian strata of Southeastern Alaska, andesitic volcanics are interbedded with sediments consisting largely of limestone with some interbedded calcareous sandstones. The volcanics include flows—in part with pillow structure—breccias, and tuffs. At several localities the pillow lavas are definitely overlaid and underlaid by limestones or calcareous sandstones carrying marine fossils. The sandstones occasionally carry carbonized plant remains.

The Triassic rocks are well exposed on the northwest end of Kupreanof Island and in the vicinity of the northern portion of Keku straits. They show the marine origin of the pillow lavas extraordinarily well. There are three groups of rocks here: one consisting wholly of marine sediments, and the other two of volcanics and a little intercalated marine sedimentary material. The two groups of volcanics are separated on the basis of their faunas, for their structural relations are too imperfectly known, and their characters over wide areas are too similar, to separate them otherwise. They comprise andesitic flows, breccias, and tuffs, with local intercalated sedimentary beds. A thickness of 1,400 feet was measured at one place with the top not shown. The lavas predominantly show a pillow structure, but are in part normal massive amygdaloidal or columnar-jointed flows. The breccias often have a limestone matrix, and are in considerable part the result of a primary disaggregation of radially jointed pillows—an autoclastic structure.

Northwest and southeast of Kake on Kupreanof Island, the volcanic series consists of pillow lava flows from 5 to 25 feet thick, massive and columnar-jointed flows from 10 to 30 feet thick, and sedimentary beds from an inch to 10 feet thick, with beds several feet thick most common. The sediments consist of interlayered black fossiliferous calcareous slate, quartzite, and limestone. *Pseudo-*

monotis subcircularis and *Halobia* are common fossils. On the north side, near the head of Hamilton Bay, the interstices between the pillows are filled with limestone. On Turnabout Island there is a 50-foot bed of gray sandstone intercalated in the volcanics. The sandstone contains intercalated layers of calcareous sandstone and conglomerate 1 inch to several inches thick, some of which bands are highly fossiliferous with marine shells and also with traces of carbonized plant stems.

On the northeast end of Kuiu Island, the other group of volcanics is well exposed. The basal portion consists of interbedded fossiliferous limestone, andesitic tuffs, and lavas with local conglomeratic limestone. These pass upward into a series consisting of basaltic and andesitic lavas, breccias, and tuffs, with interbedded limestone. The latter is locally sparsely conglomeratic with andesite pebbles. Pillow lavas, with interstitial limestone in the pockets, are seen to pass gradationally upward into breccias with a limestone matrix, and no dividing-line between the two is apparent. The interbedded limestones locally carry marine fossils. At two localities pillow lavas were found with layers of interstitial limestone up to a foot thick molded to the surface of the pillows. The limestone at the contact is slightly sintered to a pinkish-brown hornstone, and is exceedingly rich in well-preserved marine fossils.

The Kenai series of rocks in Southeastern Alaska are, on very good data, believed to have accumulated in an intermontane basin or valley. There are no marine fossils, but, on the contrary, petrified stumps and tree trunks are found in place and abundant fossil leaves in the sediments. Volcanics are abundant, but there are practically no pillow lavas.

The series comprises three groups of rocks. The lower member consists of about 1,350 feet or more of sandstone, with intercalated conglomerate beds. Above this is about 1,500 feet of rhyolite breccias and tuffs, lava conglomerates, and associated basaltic and andesitic volcanics. The third member comprises dominantly basaltic and andesitic lavas with minor intercalated breccias, tuffs, and lava conglomerates to a total thickness of over 2,000 feet. Locally, sandstone beds with fossil-leaf impressions, and thin coal beds, are interbedded with the volcanics as on Admiralty Island. At only one local-

ity was anything at all like a pillow lava observed. The exposure was small and too obscured to make out the relations. Columnar and massive amygdaloidal flows are practically the exclusive types of lava flows.

In contrast to the lack of pillow structure in the subaerial Eocene lavas of Southeastern Alaska, this structure is reported by Clapp[1] to be common in the submarine Eocene volcanics (Metchosin volcanics) of the south end of Vancouver Island. Sandstones interbedded with the breccias of this formation carry marine fossils, and the volcanics are believed by Clapp to be largely of submarine origin.

In conclusion, it appears to the writer that at the present time, in view of the number of very positive cases of the proved submarine origin of extensive pillow lavas at localities all over the world, there is no warrant for assuming a subaerial origin for pillow lavas, where they are developed in quantity over a wide area, until there shall have been brought forward evidence of a similar very positive kind to prove that such may be the case. It does appear to have been definitely proved that a structure identical or akin to that of pillow lavas has been seen to form in lavas on the surface from modern volcanoes; so that the problem involves not so much the mere presence or absence of the structure as the quantitative element. Geologists familiar with the subaerial Tertiary volcanics of North America must have contributions which they can make to this subject.

[1] C. H. Clapp, "Sooke and Duncan Map Areas, Vancouver Island," *Can. Geol. Surv. Mem. 96* (1917), pp. 260–90.

ARAGONITE CONCRETIONS FROM THE KETTLEMAN HILLS, CALIFORNIA

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The Cretaceous and Tertiary strata of the California Coast Ranges have yielded a great many different types of concretions, most of them still undescribed. All are likely sometime to be considered worthy of thorough petrographic study for the light they will throw on the conditions of deposition and the subsequent history of the inclosing rocks. At the present time, however, I propose merely to give a brief description of one unusual type of concretion, composed of aragonite, a material rarely found in concretions.[1]

These concretions have been found in a single locality, in Sec. 10, T. 25 S., R. 19 E., near the south end of the Kettleman Hills, in northwestern Kern County. They occur on a fairly prominent ridge, which bears on its highest point, set in an outcrop of massive limestone, the United States Geological Survey benchmark 505, a feature unfortunately not shown on the topographic map of the Lost Hills quadrangle. The concretions are weathered out along a strip of bare ground a few feet wide and over 400 feet long, the length of which is parallel to the strike of the limestone bed near by. The concretion horizon lies about 20 feet stratigraphically below the limestone, which carries marine fossils of the *Pecten coalingensis* zone (Upper Etchegoin).

Some shallow pits showed that the concretions occur in a zone a few inches thick, in a bed of fine, poorly washed sand or silt; the zone dips about 25°, or as much as the limestone bed above it. One pit showed no gypsum with the concretions, but in the other one they were set in and upon a bed of crystalline gypsum which inclosed some sand. The smaller concretions, which in general have the largest and best-developed crystals, occur chiefly near the south

[1] W. A. Tarr, in Twenhofel and Others, *Treatise on Sedimentation* (Baltimore, 1926), p. 499.

end of the zone; larger concretions, some about 6 inches in greatest dimension but with smaller and poorer crystals, are found toward the north end. Many of the larger concretions were broken when dug out, the fractures being old and weathered. A great many, including some small specimens, have hollow interiors with radiating cracks which become narrower and disappear toward the surface. The walls of the cavities are generally set with very small, platy crystals of aragonite. These were at first supposed to be calcite crystals, but examination with the binocular and polarizing microscopes disproved the supposition.

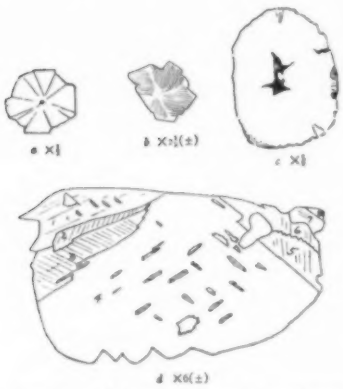

FIG. 1.—(*a*) Section through interior of small concretion; shows small central cavity and radiating crystals. (*b*) End of single crystal, showing striations. (*c*) Interior of medium-sized concretion, with drusy cavity. Radiating crystals shown in a few places only. (*d*) Thin section parallel to end of a twin crystal. Largest individual penetrated by two others with different orientations. All sketches freehand.

A great many of the crystals composing the exterior of the concretions are stubby prisms with flat ends which show evidence of being compound (Fig. 1*b* and *d*). Different portions of the surface reflect the light differently; some lines are etched out, presumably by differential solution. Etching of similar character gives the sides of the columns a striated appearance. A thin section cut parallel to an end face (Fig. 1*d*) shows ragged edges between the various individuals composing the twin. It shows, further, that one large crystal has patches of two others with different orientations scattered through it. In some of the larger concretions there are a great many crystals that are either simple or twinned differently from the stubby prisms just described. Most of them are small, and many imperfect. Only the twinned prisms seem to influence the interiors of the concretions to an appreciable extent. Polished sections through the centers of some of the smaller specimens show that the crystals may

extend nearly to the centers (Fig. 2*c*). Similar sections across larger concretions, or those with crystals of a different kind, show in the

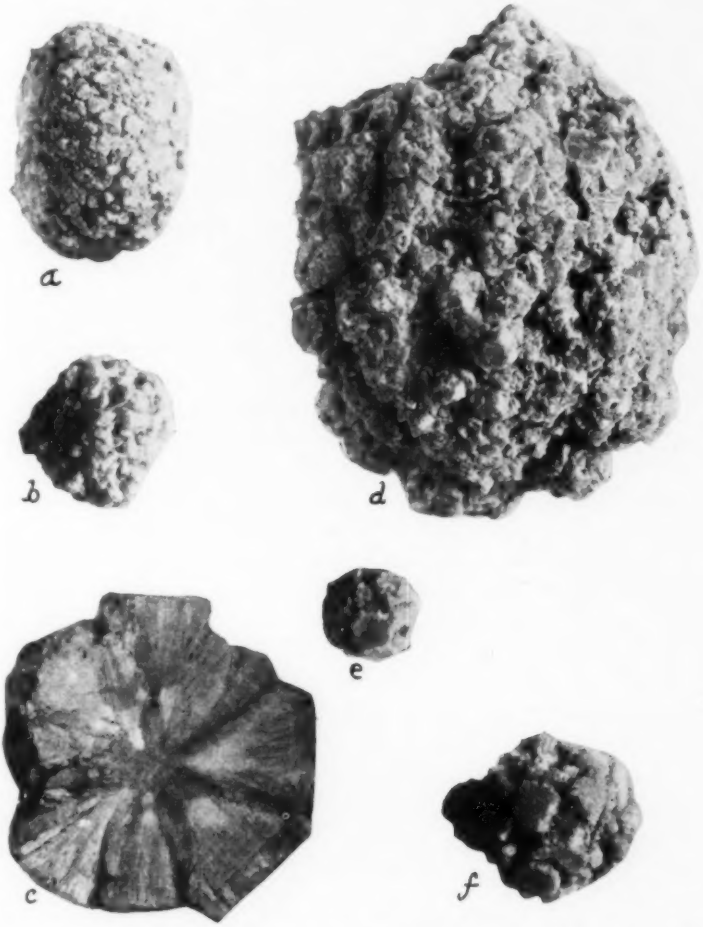

FIG. 2.—Aragonite concretions. *c*, photographed by F. G. Tickell, shows the interior of a small specimen on a somewhat enlarged scale. Not all the concretions have as good crystals as those figured.

interior only a dense mass of aragonite in which individual crystals are unrecognizable. Some thin sections were made of well-crystallized concretions, but they show little of great interest except the lines of brown, flaky impurities gathered along the contacts between the various prisms. The nature of this material has not been determined; it looks like ferruginous clay. No grains of quartz or feldspar have been noticed in any section.

The statement has already been made that this occurrence of aragonite is the only one known in California Tertiary strata. Lenses of dense, structureless limestone and bands of calcareous nodules are common, however, throughout the Upper Etchegoin formation. The source of the calcium carbonate is thus not an important phase of the problem of the origin of these concretions. The chief point that needs consideration is the conditions that allowed aragonite to be formed, rather than calcite; it would also be interesting to know why the aragonite took the peculiar shapes that are now found.

The clean interiors of the concretions and their occurrence at a definite stratigraphic horizon suggest that they may have been formed contemporaneously with the strata in which they are now found. If so, they are to be accounted for by chemical reactions taking place between some of the materials that formed the bottom of the Etchegoin Sea, and the sea water. The probability that we are dealing with a portion of the sea so inclosed as to have a temperature and salinity very different from those of ordinary sea water should of course be kept in mind. As to the particular reactions involved, the following sentences from Cole furnish a basis for what is perhaps the most satisfactory hypothesis of the origin of these concretions:

> Ammonium carbonate . . . . derived from the decay of organisms, or sodium carbonate, will precipitate calcium carbonate as aragonite from the calcium sulphate and chloride . . . . of salt water. Films of aragonite are at present accumulating by this process on the floor of the Black Sea, and marine oölitic grains, also consisting of aragonite, are produced by the same reaction.[1]

There is a surprisingly close superficial resemblance between some of these aragonite concretions and a large marlyte nodule de-

[1] G. A. J. Cole, *Rocks and Their Origins* (Cambridge University Press, 1922), p. 17.

scribed and figured by Kindle,[1] and considered to be a product of algal action. A similar origin cannot be demonstrated for the former. The cavities suggest that the concretions began as colloidal masses, however, and that as they increased in size the interiors dried and cracked while the outer surfaces were kept moist.[2]

The gypsum locally occurring with the concretions, like other veins and crystals of gypsum in the Etchegoin and associated formations, is apparently epigenetic. Gypsum sometimes replaces the calcium carbonate of fossil shells in the Kettleman Hills, but there is no evidence in this instance that it has replaced any of the aragonite of the concretions.

[1] E. M. Kindle, "The Physical and Biological Characteristics of Certain Types of Marlyte Balls from Manitoba and Michigan," *Proc. and Trans. Roy. Soc. Canada* (1923), pp. 105–16, esp. Plate I.

[2] For illuminating discussions of this subject, see the following: W. A. Richardson, "On the Origin of Septarian Structure," *Mineralogical Magazine*, Vol. XVIII (1919), pp. 327–38, and F. Bernauer, *Die Kolloidchemie als Hilfswissenschaft der Mineralogie, usw.* (Berlin, 1924), pp. 5 and 6.

NOTES ON THE LARAMIE FORMATION IN CENTRAL WELD COUNTY, COLORADO

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Several years ago while engaged in revising the geologic map of northeastern Colorado, there were discovered at two localities in the region of Laramie outcrop, horn cores and fragmentary limb bones of dinosaurs that strongly suggested Ceratopsian remains. The material, after preliminary study at the University of Colorado, was submitted to Dr. C. W. Gilmore of the United States National Museum for an opinion which verified the writer's determination of the horn cores as probable Triceratops remains. The limb bones are not sufficiently complete to be accurately identified, but the large size suggests that they too may be related to the genus Triceratops. One of the cores was found about two miles north of Briggsdale in central Weld County by Professor Henderson and the writer; the other some 12 miles northeast by a party under Mr. J. W. Vanderwilt of the Colorado Geological Survey.

Inasmuch as identifiable dinosaur remains were previously unknown from the Laramie of the Denver Basin, the discoveries are of considerable interest because they suggest the correlation of the Laramie of eastern Colorado with the Lance formation of the Dakotas and Wyoming. In the early part of June of this year, Professor Henderson and the writer revisited the region near Briggsdale in an attempt to discover other remains and to locate those at hand definitely in the section as exposed in the area. Except for a small outlier of Oligocene (White River) beds on the higher areas north of Briggsdale, the surface of central Weld County is underlain by beds of Laramie age. The prevailing opinion has assigned a thickness of approximately 200 feet to the formation, but the recent investigation indicates the presence of about 400 feet of Laramie. The section consists of alternating sandstones, shales, lignitic shales, and impure

lignites, and changes rapidly from place to place laterally. North of Briggsdale the upper 75 to 100 feet contain no lignitic beds and it is this portion which yielded the vertebrate bones. The Triceratops(?) horn core was found approximately 30 feet above the last lignite exposed. A careful study of the vicinity failed to reveal invertebrates of any kind above the dinosaur horizon, but below it to the south and west along the valley of Crow Creek numerous collections of typical Laramie fossils were made, several species of *Corbicula*, *Corbula subtrigonalis*, and *Ostrea glabra* being abundant at certain horizons. Most of the invertebrate localities are considerably below the horizon at which the horn core was found.

The place at which the second core was found was not visited on the recent trip but, according to Vanderwilt, the dinosaur remains there also were above horizons yielding Laramie invertebrates.

The chief significance of the discovery of identifiable Ceratopsian remains in the Laramie is the suggestion that the upper part of the Laramie of northeastern Colorado is to be correlated with Ceratops-bearing portion of the lower Lance beds of the western Dakotas and Wyoming. This correlation has long been suspected by Henderson, George, and others of the University of Colorado, but no faunal evidence has hitherto been available.

Field studies over the past several years have brought to light other facts bearing upon the origin of the Laramie formation in northeastern Colorado. At several places along Crow Creek near Briggsdale, about Greasewood Lake to the east of Osgood, and according to R. D. George, State Geologist, at several other places in Weld County, there are exposures of Laramie sandstones that exhibit cross-bedding such as is commonly found in eolian sands today. This seems to strengthen the idea held by the members of the Colorado Geological Survey that the Laramie beds originated upon broad coastal flats upon which conditions were constantly changing. At all places where the writer has seen the eolian characteristics, beds at the same horizon only a short distance away may be lignitic clay, or even contain brackish water fossils. The conditions indicate that terrestrial and subaqueous deposition was going on at the same time over much of the area now covered by the formation but that neither continued uninterruptedly for any great length of time.

FACETED SANDSTONE PEBBLES OF THE NORTH RIVER NEAR LEXINGTON, VIRGINIA

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ABSTRACT

The facets of certain sandstone pebbles of the North River near Lexington, Virginia, were found to represent well-cemented fracture surfaces modified by abrasion. Their history advises caution in attempting to relate faceted pebbles to specific processes of sedimentation.

The faceted pebble viewed as a result of sedimentary processes and as a key to the history of sediments formed by processes no longer active has cast its charm into the writings of some of the foremost students of sediments: Walther, Davis, Gregory, Wentworth, and others. Observers of processes still in operation find that such pebbles may be formed by the wind-swept sands of the desert, glacial abrasion, stream-borne sands, the surf acting on captive pebbles, the churning motion of water in potholes, and other agencies. They also find that the primary characteristics of the pebble before transportation may influence its final shape, quite as much as abrasive agencies.

Studies of the genesis of faceted pebbles fashioned by processes no longer in operation reveal two distinct mental tendencies. The one, relying more on reasoning than on the observation of present-day processes, is inclined to give weight to the faceted pebble as an index of specific sedimentary processes. The other, placing more faith in observation of processes still active, minimizes its authority. To it, the faceted pebble may be the final result of a number of agencies and conditions, whose separate influences are difficult to gauge. It finds that the shape of the pebble may be influenced by its original shape, by internal structures, and perhaps by several processes of sedimentation.

Faceted pebbles owing their shape mainly to structures acquired before transportation are common in the North River near Lexing-

ton, Virginia, and seem to be of enough significance to warrant a brief description of their occurrence. The history of these facets emphasizes the value of considering other factors besides sedimentation when interpreting faceted pebbles buried in ancient sediments.

The North River breaks through North Mountain at Goshen Pass, a gorge cut out of the Ordovician Massanutten sandstone, about 14 miles northwest of Lexington, Virginia. (See Lexington Quadrangle sheet of the Federal Survey.) It flows southeastward a distance of about 20 miles across the Valley of Virginia, where it has entrenched itself in a terrane of folded and faulted Cambro-Ordovician limestones, dolomites, and shales. Turning southward, it follows the strike of the formations along the western base of the Blue Ridge to its junction with the James River at Balcony Falls.

Through Goshen Pass and across the valley, it is actively cutting downward, numerous small rapids and rock outcrops appearing in its bed. The grade varies from less than 20 feet to the mile to more than 100 feet, the steepest grades being in the pass. Its flood plain and stream-bed deposits are thin and average less than 10 feet in thickness. Through the pass, the débris is coarse and bowldery. Near Lexington, bowlders are in the minority. Pebbles 3 or 4 inches in diameter are dominant.

Although the river flows over a limestone and dolomite terrane throughout most of its course, pebbles from this source are in the minority. The Massanutten sandstone at the pass furnishes most of the débris lodged along the stream bed. White sandstones and red varieties, in texture ranging from sugary to quartzitic are dominant. Conglomeratic and flaggy varieties also occur. The white ones are nearly pure quartz. Cherts, derived mainly from the dolomites, are also abundant.

Only the white sandstones are commonly faceted, but occasionally facets are found on the compact, red kind. No facets were seen on the flaggy and conglomeratic sandstones, nor upon the limestones and dolomites. In fact, the calcareous rocks usually show little or no rounding, excepting the pure types. The cherts are mostly angular, but some show facets due to joints.

The facets of the sandstone pebbles are usually smooth, waterworn surfaces. The grain on the facets is more compact and quartz-

itic than on the rounded, sugar-textured surfaces which they bevel. One or more facets may be present on a pebble. In cases where there are several, they may intersect and form distinct edges. In some, the facets are isolated. The lower left-hand pebble in Figure 1, for example, has a large facet facing the front and another small isolated facet cutting the left-hand apex.

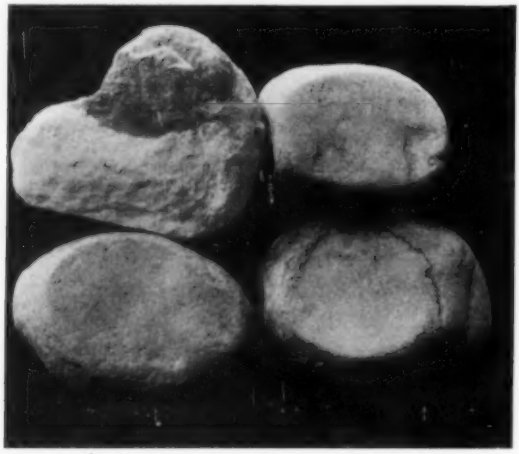

FIG. 1.—Faceted pebbles from the North River near Lexington, Va. About one-half natural size. The facets are smooth and water worn. The grains are better cemented on the facets than on the rounded surfaces. The pebble on the lower right shows a smooth fracture surface outcropping on the facet along a sinuous line. The one on the upper left is broken open to show a smooth, well-cemented fracture surface. The facets are interpreted as representing abraded, well-cemented fracture surfaces.

In situ, the pebbles are found lying helter-skelter with respect to their facets; facets may lie face up or down or sidewise. Nor do they show any relation to stream activity. On the hypothesis that they were cut by stream abrasion, they were looked for in potholes and along the stream bed, where pebbles might have been held captive between bowlders or in rock clefts. None were found in places where water could have scoured them continuously along one plane so as to form a facet. Facets formed in this way on pebbles would seem to be exceptional.

Most of the faceted pebbles are free from fracture planes. Excepting the greater compactness on the facets, these show nothing to suggest any other agent than stream abrasion as the cause of the facets. Some, however, are cut by fracture surfaces. Some facets extend into the interior of the pebble as fracture surfaces. These give the clue to the problem. The lower right-hand pebble in Figure 1 is this type. The dark, sinuous line extending from the upper margin of the facet across its right marks the outcrop of a fracture plane which merges with the facet. The indentation on the right is due to another fracture. The pebble on the upper left was broken to show the smooth surface of the fracture traversing it. Such fractures slice the grains, and the cementation along such surfaces is better than away from them. This is in accord with the fact that the cementation along the facets is better than on the rounded surfaces.

The facets of these sandstone pebbles were not formed by stream abrasion alone. They are fracture surfaces, better cemented than the rest of the rock. The pebbles broke along these surfaces. Stream abrasion modified the exposed fracture surfaces to such an extent that their history is not obvious in all cases. The history of these pebbles may therefore add to the caution which seems advisable in attempting to correlate pebble facets with specific processes of sedimentation.

PETROLOGICAL ABSTRACTS AND REVIEWS

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University of Chicago

HATCH, F. H. *The Petrology of the Igneous Rocks.* 8th ed., revised with the assistance of A. K. WELLS. New York: The Macmillan Co., 1926. Pp. 566, figs. 144.

This eighth edition of Hatch's *Petrology of the Igneous Rocks* has been increased from 454 pages in the seventh to 566. The increase seems to be greater, however, on account of the use of larger type and much thicker paper. In the main, the author has adhered to the general plan of the previous edition, although there is revision in every part, and considerable rearrangement. The book is now divided into six instead of four parts, Part III, "The Consolidation of Igneous Magmas and the Textures That Result Therefrom," and Part V, "Metamorphism of the Igneous Rocks," being new. The first has the section on the "Consolidation of the Magma" newly added; the second portion on textures, however, is simply transferred from another place in the previous edition. Part V is expanded from the fifth chapter of the old Part III, the "Changes in Composition Subsequent to Consolidation" being newly added.

In Part I on "The Origin, Occurrence, and External Structures of the Igneous Rocks" the descriptions of the forms of intrusions of plutonic rocks are considerably expanded, and Daly's genetic classification is followed. While a reference is here made to Cloos's work, no brief of his theory is given. However, the book is intended only for an elementary text and much must be left out. Maare or diatremes are not mentioned.

Part II is devoted to "The Constituent Minerals of the Igneous Rocks." Since there are numerous elementary works dealing solely with the rock-forming minerals, one might wish that these 89 pages had been used instead for an expansion of the parts dealing with petrogenesis. Under the feldspar descriptions, Hatch speaks of Calkins' limiting compositions of the plagioclases. The same percentage values were used three years earlier by the writer of this review in his *Manual of Petrographic Methods* (1st ed.) on page 278; the words "Modifiedfrom Rosenbusch-Wülfing" in the legend below the cut refer to this change. The divisions at 0–10–30–50–70–90–100 per cent An, as shown by Calkins, are well

worth following, and after apostatizing in his *Essentials for the Microscopical Determination of Rock-forming Minerals and Rocks* (Chicago, 1922, p. 42, and Figs. 23 and 24), the reviewer is coming back to the use of the divisions at the even tens. It would be desirable if the end members were not given the same names as the pure end molecules. Perhaps "sodaclase" and "calciclase" would do for 0–10 and 90–100 An.

As mentioned above, the twenty pages on "The Consolidation of Igneous Magmas," in Part III, are practically new. Here is a very brief account of eutectics and the crystallization of minerals from a magma, part of which was given in Part I, chapter iii, of the seventh edition.

Part IV treats of "The Classification of Igneous Rocks." The term "femic," which should be applied only to the hypothetical minerals of the C.I.P.W. norm, is here misused for dark minerals in general—a very common error pointed out by the reviewer in this *Journal* (XIX [1911], 319 n.). C.I.P.W. later suggested "mafic" for "ferromagnesian minerals."

The rock classification used by Hatch is the same as that in the seventh edition. As there, so here also, the classification is partly mineralogical and partly chemical, for the different families are based largely on the silica content. This makes granodiorite, for example, not a rock intermediate in mineral composition between granite and diorite, as originally intended, but a diorite with SiO_2 over 66 per cent. Hatch does not accept the now common use of tonalite (originally used for a quartz-mica-diorite) for quartz-diorite, but thinks of this as a granodiorite low in silica (p. 210). He separates his diorites from his gabbros by the silica content. Thus he says (p. 228): "With more than 60 per cent the diorites pass into the granodiorites, and with less than 52 per cent into the gabbros." His diorites have plagioclase ranging from oligoclase to labradorite, his gabbros "basic plagioclase, generally labradorite, but occasionally bytownite or anorthite. Some oligoclase or andesine may be present in subordinate quantity" (p. 245).

The grouping of the rocks has been changed so that now the plutonites are followed by the extrusives, and these by the hypabyssals. As the extrusive equivalent of adamellite he gives toscanite (orthoclase plus basic plagioclase) and not dellenite, the original term used by Brögger. Trachyandesite, as the extrusive equivalent of monzonite, is objectionable from the use made of the term by Rosenbusch. For that reason alone latite is preferable.

To Part V, "Metamorphism of the Igneous Rocks," 18 pages on pneumatolytic changes (tourmalization and kaolinization), hydrothermal metamorphism (albitization, analcitization, and silicification), contact metamorphism, injection and contamination, dynamometamorphism

(saussuritization, sericitization, uralitization, chloritization, and epidotization), and weathering have been added.

Part VI treats of the "Distribution in Space and Time of the Igneous Rocks." The first chapter, of 10 pages, is on petrographic provinces. The remaining 115 pages are devoted to the cycles of igneous activity in the British Isles. This corresponds to pages 323–429 of the seventh edition, but it has been entirely rearranged and re-written. In the former edition Hatch grouped the distribution of granites, distribution of syenites, distribution of aplites, etc., etc., in different parts of the British Isles; each class of rocks by itself. In the present edition the divisions are made as to volcanic activity in pre-Cambrian, Ordovician, Devonian, Carboniferous, early Permian, and Tertiary times.

The "Table for the Determination of the Chief Minerals of Igneous Rocks in Thin Sections," in the Appendix, is the same as before.

The "Index of Names of Igneous Rocks" has been made very useful by short definitions, which makes it serve as a glossary.

A very useful and helpful book for beginners in petrography, one of the best small books on the market. Numerous footnote references are valuable for further study.

ROSENBUSCH-WÜLFING. *Mikroskopische Physiographie der Mineralien und Gesteine.* 5th ed., second and third sections. Stuttgart: E. Schweizerbart'sche Verlagebuchhandlung, 1924. Pp. 253–847; 12 plates; 488 figs.

The first section of this book was reviewed previously in this *Journal*. The present two sections complete the volume of petrographic methods. The changes from the 4th edition have been so many that it is impossible to enumerate them all, but the extent of the additions may be seen by a comparison of the 467 pages of the preceding edition with the 847 pages of this. The additional material is, in itself, a measure of the advancement made in petrographic methods in the past twenty years. Throughout the book, the theoretical and practical parts, which were formerly considered separately, have been united, making the examination of any subject much more convenient. Only a few examples of the additions can be here given: thus, the chapter dealing with lenses has been extended from 19 to 53 pages; hand lenses, from 3 to 12, the course of light through the microscope, from $1\frac{1}{2}$ to $16\frac{1}{2}$; the immersion method for measuring refraction, from 12 to 21; the Fedorow method, from a couple of pages to 34.

The book is absolutely indispensable in every petrographic laboratory, and none other in any language is so complete.

REVIEWS

Fosseis terciarios do Brasil com descripção de nuovas formas cretaceas, Vol. IV. By Carlotta Joaquina Maury. Brasil Serviço Geologico e Mineralogico Mon., 1925. Pp.711; 24 plates; map.

This handsomely illustrated monograph, which has Portugese and English texts on opposite pages, brings up to date all that is known of the Tertiary fossils of Brazil. It also contains a summary of the stratigraphy and correlation of the Cretaceous deposits of Brazil and descriptions of some Cretaceous fossils from new localities. The localities that yielded the fossils are described in an appendix by Dr. Gonzaga de Campos, director of the Brazilian Geological Survey. Dr. Maury's earlier work on the fossils of Trinidad, Venezuela, the Dominican Republic, and Porto Rico served as an invaluable background in the description of the fossils and in the interpretation of their age.

This report is devoted principally to the Lower Miocene fossils found at the mouth of Rio Pirabas and at the agricultural station on the railroad from Bragança to Belém. Both these localities lie in the state of Pará, near the mouth of Rio Pará. The locality on Rio Pirabas, exposed only at low tide, was discovered in 1876, but the other locality was not discovered until 1908, when fossiliferous beds were penetrated in a well. Later the Brazilian Geological Survey made an excavation at this place. The early collections from Rio Pirabas were described in 1887 by C. A. White,[1] who lumped these fossils, and also Eocene fossils, with undoubted Cretaceous fossils, and called all of them Cretaceous. During a visit to Rio de Janeiro in 1913 Dr. Maury discovered that the fossils from Rio Pirabas are of Tertiary age, and she later published a preliminary note relating to them.[2] Of the 206 species of mollusks from Rio Pirabas, 142 are described as new species, and of the 44 species from the agricultural station, 31 are new. At both localities the fossiliferous beds are limestones and the specimens are almost wholly internal and external molds. The descriptions and figures are based principally on artificial casts made from external molds It is evident that a great deal of exacting labor was required in studying

[1] Charles A. White, "Contribuições á paleontologia do Brasil," *Mus. Nac. Rio de Janeiro Arch.*, Vol. VII (1887). Pp. 273; 28 plates.

[2] Carlotta J. Maury, "A New Marine Tertiary Horizon in South America," *Science*, New Series, Vol. XLVIII (July 5, 1918), p. 14.

this unsatisfactory material, and in view of the unpromising raw collections it is surprising that so much could be learned about these fossils. But perhaps they are a little overworked. Some of the scraps that are described as new species are hardly recognizable. *Cylindritella*, a new genus described by White, turns out to be molds of *Marginella*, and White's *Piestocheilus* is a *Mitra*. It is unfortunate that not all the species from Rio Pirabas described by White are considered in this monograph. White failed to designate type localities, and he recorded several species from Rio Pirabas (Rio Pirabas of White) and also from Cretaceous or Eocene localities. It still is unknown, for example, what White had from Pirabas that he called *Gerivillia dissita*. One of White's species (*Cancellaria calypso*)not mentioned by Dr. Maury was recorded only from Rio Pirabas. The conclusion that the fossils from Rio Pirabas are of Lower Miocene age seems to be fully justified. They are correlated with the Chipola formation of Florida and the Baitoa formation of the Dominican Republic. These desposits, and also the Thomonde formation of the Republic of Haiti and the Quebradillas limestone of Porto Rico, are the youngest beds carrying *Orthaulax*, which is represented in the Pirabas formation, as Dr. Maury calls the Rio Pirabas beds, by a new species very similar to *Orthaulax aguadillensis* Maury from Porto Rico and Haiti. There is a possibility that the Pirabas formation is a little older than these deposits, for in tropical America and Florida Turritellas similar to *T. meunieri* and *T. paraensis* are found in beds one stage older (Tampa formation of Florida, Anguilla formation of Anguilla, upper part of Culebra formation of Panama, Machapoorie beds of Trinidad). The fossils from the agricultural station also are called Lower Miocene, but Dr. Maury suggests that they may be a little younger than the Pirabas fossils on account of the absence of *Orthaulax*, though this negative evidence is inconclusive. Only thirteen species are found at both localities —and some of them are doubtful—so there is only a slender basis for direct comparison.

A new species of *Anomia* and an undertermined crocodile tooth are the only fossils described from Pirapemas, in the interior of the state of Maranhão. The age of these beds is left open. Seven species of mollusks, most of which are still living, are described from Pliocene or Pleistocene beds cropping out on Tury-Assú Bay. The Eocene deposits of the states of Pernambuco and Rio Grande do Norte are briefly reviewed. They are correlated with the lowest fossiliferous beds on Soldado Rock in the Gulf of Paria, which Dr. Maury considers of Lower Eocene (Midway) age, though it should be remembered that they may be Middle Eocene (Clai-

borne).[1] The fossils found at Pebas and other places along the upper tributaries of the Amazon in eastern Peru and western Brazil also are briefly reviewed. These interesting fossils deserve fuller consideration than is given in this report. A paper by Dall[2] and another by Conrad[3] are omitted in the review of the literature. A report on those fossils was issued by the Brazilian Geological Survey[4] while Dr. Maury's monograph was in press. No less than thirteen new genera and subgenera of mollusks have been described from this fauna. The most interesting of these fossils is the peculiar corbuloid genus *Pachyodon* (also known as *Anisothyris*) which embraces not only *Corbula*-like species, but also *Leda*-like, *Isocardia*-like, and *Tellina*-like species. Some of the mollusks found in these beds are land snails, others are undoubted fresh-water dwellers, and most of the others probably lived in fresh water or in slightly brackish water. Although the names of a number of marine genera have been given to some of these shells, the only one that has a convincing marine appearance is *Purpura woodwardi* Roxo (*Rapana?*). Various guesses have been made as to the age of these beds, but they now are generally regarded as Pliocene.

Cretaceous mollusks and echinoids from several new localities in the state of Rio Grande do Norte are described. These deposits are tentatively regarded as Turonian. *Gonzagia*, a new subgenus of *Nerinea*, is dedicated to the Director of the Brazilian Geological Survey. One of these localities yielded some fossil plants, three new species of which are described without any comparisons, and all the generic determinations are questioned. A new locality in the state of Bahia furnished other Cretaceous fossils that are described. It is suggested that these beds are of Albian age. A review is given of the non-marine Cretaceous beds of the state of Bahia. Age assignments for these beds given by different writers range from Neocomian to late Upper Cretaceous, and some of the fossils have even been regarded as Tertiary. Several stages, probably ranging from upper Albian to Turonian, are represented in the Cretaceous deposits of

[1] H. G. Kugler, "Das Eozänprofil von Soldado Rock bei Trinidad," *Eclogae geol. Helvetiae*, Vol. XVIII (1923), pp. 253–59; 3 text figs.

[2] W. H. Dall, "Note on the Genus *Anisothyris* Conrad, with a Description of a New Species," *American Journal of Conchology*, Vol. VII (1871), pp. 89–92, Plate 16.

[3] T. A. Conrad, "Description of Two New Fossil Shells of the Upper Amazon," *Proceedings Philadelphia Academy of Natural Science*, Vol. XXVI (1874), pp. 82–83, Plate 12.

[4] M. G. de Oliveira Roxo, "Breve noticia sobre os fosseis terciarios do alto Amazonas," *Brasil Serviço Geologico e Mineralogico Bull. 11* (1924), pp. 41–52; 1 plate.

the state of Sergipe, the fossils of which were described by C. A. White. Some new species are described from one locality. *Sergipia*, a new section of *Inoceramus*, is based on material from this locality.

Dr. Maury's monograph will be a standard reference for the Cretaceous and Tertiary fossils of Brazil and will be very useful to all who are interested in the geology of tropical America.

W. P. WOODRING

The Geology of Oil, Oil Shale and Coal. By MURRAY STEWART. London: Mining Publications, Ltd., 1926. Pp. 104, figs. 3. 7/6*d*.

This book is of interest because it is based primarily on studies in far-away Burma, and because it presents various stimulating hypotheses and interpretations at variance with those commonly held. The general point of view of the author is that

> although oil and coal are two very different substances, the conditions that determined the formation of one were often so closely related to those that determined the formation of the other that both were apparently part of more general conditions under which coal accumulated collaterally with oil.

For coal, the author believes that carbonization of vegetable matter took place in fresh-water swamps or lagoons under the action of carbonizing bacteria, and on such swamps or lagoons being drained, the products were carried by rivers into estuaries, or the open sea, in the form of a black, carbonaceous mud, which was laid down as a sediment. According to this view, the composition of a coal seam was largely original, and after the coal accumulated as an ordinary geologic sediment there was little or no change in its composition.

The author advances the view that oil from organic decomposition becomes mechanically mixed with fine mud particles in running water, is carried to sea and deposited some distance from the shore as a deposit of fine mud containing oil globules. Dolomitized limestones, he believes, accumulated in salt lagoons or portions of the ocean where the bottom waters were stagnant. Such stagnant places are characterized by accumulations of organic matter, by the development of hydrogen sulphide, and by the disappearance of bottom-living animal organisms. "Such bottom waters are taken possession of by sulphur-making bacteria which feed on the micro-organisms and other life that falls from the sun-lit oxygen absorbing surface zone." The "sulphur-making" bacteria reduce

sulphates to sulphides. Magnesium sulphide, reduced from the sulphate, reacts with water to produce magnesium hydroxide and hydrogen sulphide. The magnesium hydroxide is believed by Stuart to combine with the calcium carbonate deposit on the sea floor to dolomitize the limestone. Further appeal is made to the activities of the sulphate-reducing bacteria to form petroleum out of the dead protoplasm by extracting some of its oxygen and fixing hydrogen on to it. Free sulphur is liberated in the involved reactions, and to this is assigned the presence of sulphur in limestone oils. The increased salinity and deficiency in sulphates and magnesia in oil-field salt waters, compared with modern sea water, are used as corroborative evidence.

Stuart calls attention to the common bluish color of clays, shales, and sandstones of marine origin, which he says is due to extremely finely divided iron disulphide. For explanation he turns to the sulphuretted hydrogen generated as the result of bacterial action.

> Since the sulphur-making bacteria seem to be essentially inhabitants of salt water, this would account for the general bluish color of marine detrital deposits as contrasted with the yellow, brown, or reddish color of detrital sediments accumulated under fresh water conditions.

Many other suggestive ideas appear in this work, though many of the arguments are not very convincing.

R. T. C.

The following communication from Mr. Tenney Frank, of the American Academy in Rome, will bring to the attention of the American paleontologists a publication which should have a wider circulation in this country:

> Some of Pigorini's students have revived the *Bulletino di Paleontologia Italiana*, which for over forty years has published brilliant researches and discoveries in the field of prehistory. Since they have secured only five subscribers in America, they have asked me to aid them in bringing the attention of scholars and institutions to its revival. The cost is less than two dollars per year (35 lire). Address Dr. Ugo Antonielli, Museo Preistorico, Rome, Italy.

S. W.

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"One day there was a great festival. . . . . The weaver and the carpenter put on their best things, and in the squares and courtyards inspected the faces of people dressed to kill. And they caught a glimpse of a princess seated at the window of a stucco palace. . . . . Like a dream she took captive the eyes of all as she sat surrounded by girl friends.

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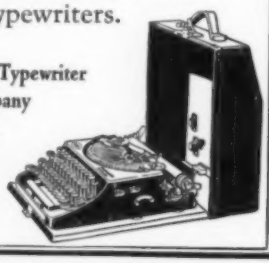

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The PRESS IMPRINT

For March 1926 and April 1926

Individualism or Socialism?

J. Maurice Clark, who gave us in *The Economics of Overhead Costs*, a pioneer work on the theme of unused capacity, makes in his new book, *The Social Control of Business*, an experiment in the interpretation of one of the most all-embracing aspects of economic life. He has analyzed the question of adjusting conflicting interests and claims of rights in modern economic life, and since individualism and socialism are the outstanding alternative schemes for accomplishing this end, he has much to say about both. Other systems of control involved are state socialism, revolutionary communism, syndicalism, and anarchism.

Mr. Clark's conclusion is that industry is a matter of public concern and that "the stake which the public has in its processes is not adequately protected by the safeguards which individualism offers." But he goes on to say, "Society does not know what it wants or cannot devise means that will secure it. Hence, the lesser evil is to let individualism hold the field. Such a situation may be regrettable but it is an evil from which we suffer less, on the whole, than from the meddling and muddling that results when the government acts without knowledge."

In this book, as in no other reference on the subject, the entire field of social control is organized and clarified for the student. A college text for collegiate schools of business, it is designed for the survey course in social control, whether it introduces advanced courses in special problems or follows them, tieing together what would otherwise remain separate bodies of material.

Chief emphasis is placed upon the problems common to trusts, railroads, and public utilities arising out of fixed capital, untraced expenses, increasing returns, and resulting tendencies to monopoly. Complementary phases of control treated are common law, statute law, and codes of economic ethics.

Part II of the volume concentrates on a group of definite and tangible problems: price control, public utilities, and the question of public ownership—that is to say, a large and significant section of the entire field of economic life.

It is Mr. Clark's belief that industry has physical capacity and technical ability to produce far more than it does, but is kept short of its capacity by a failure of social co-ordination; and that the greatest field open to human invention is in making improvements in our system of social control. He has shown how the machinery of social control is actually working, and has pointed out the features of what he considers a desirable system of control.

Here is a text that not only brings to the student the theoretical aspects of the subject but also gives him a realistic picture of the underlying facts. *THE SOCIAL CONTROL OF BUSINESS.* By JOHN MAURICE CLARK. *$4.00, postpaid $4.15.*

* *

Evolution Up-to-Date

Recent years have witnessed important changes in various phases of evolutionary science. To take account of recent develop-

ments, Horatio Hackett Newman has completely revised his comprehensive treatment of evolutionary biology, *Evolution, Genetics, and Eugenics*. The new edition is entirely up-to-date, and is greatly improved from the pedagogical point of view.

The discussion of mutations, eugenics, and other topics has been revised in the light of work done since the appearance of the earlier edition. Much new material has been added. A chapter on mutations has been written especially for the book by R. Ruggles Gates, and there is a new paper by H. F. Muller. The section on eugenics has been strengthened by the addition of a lucid chapter from Albert E. Wiggam's book *The Fruit of the Family Tree*. New matter appears in Professor Newman's connecting and introductory statements, and the chapter on "Linkage and Crossing-Over" has been re-written in a more elementary style for the beginner.

Personal attendance at the trial of J. T. Scopes for violation of the Tennessee anti-evolution law has enabled Professor Newman to describe it in this new edition in connection with his general interpretation of the present anti-evolution campaign in the United States.

The order of presentation of the material has been changed from one based on the degree of directness of the evidence to one governed by the logical succession of topics. This new order gives the text added clearness and teachability.

The reading materials contain certain technical terms that are often perplexing to the beginner. This is remedied in the revised edition by the addition of a full glossary which defines nearly all the biological terms used in the book.

In a single volume, a survey of the entire field of evolutionary science—this is what Mr. Newman has achieved in *Evolution, Genetics, and Eugenics*. With original material and connective and interpretative sections, the author weaves into a unified account a well-balanced selection of excerpts from such writers as Darwin, Wallace, Romanes, DeVries, Le Conte, Morgan, Castle, Lull, Guyer, Popenoe, Shull, Downing, and Thomson.

The revised edition is the most complete and up-to-date textbook available for survey courses in the subject, and is a most readable compendium for the general public. *EVOLUTION, GENETICS, AND EUGENICS*. By HORATIO HACKETT NEWMAN. (Revised Edition.) *$3.50, postpaid $3.70.*

A Living Wage

In *Wages and the Family*, Paul H. Douglas points a way out of the *impasse* in which the living-wage principle finds itself, due to the fact that most of its adherents have used it to support the impracticable contention that men should be paid enough to maintain a "standard" family of five. He accomplishes this by championing a basic wage plus the payment of allowances for dependents.

That industry cannot be saddled with the maintenance of forty-five million fictitious wives and children, Dr. Douglas makes clear, and he argues that although industry should pay a living wage, it should not, and cannot hope to, pay all adult male workers enough to support a family of five.

He proposes three features which he believes essential to any proper wage system: the payment of an adequate basic wage, the payment of allowances for dependents, and the creation of an equalization fund to obviate discrimination against hiring those with dependents. With this latter feature there has been a great deal of experimentation in France and Germany. This book is particularly concerned with working out the details of an adequate and just system in the light of American conditions. *WAGES AND THE FAMILY*. By PAUL H. DOUGLAS. *$3.00, postpaid $3.15.*

Literary London

Of all the cities in the world, none has more interesting literary associations than London. In a series of delightful sketches, Percy Holmes Boynton has re-created for the inquiring student of literary history the London of Chaucer, of Shakespeare, of Milton, Dryden, and Addison, of Johnson, Lamb, and Byron, of the Victorian era, and of today. His *London in English Liter-*

ature is a pleasing volume, full of entertaining anecdotes, interesting bits of history, reproductions of curious old drawings, and stories of famous writers. It adds to the enjoyment of English literature by giving an understanding of the background.

Mr. Boynton presents the atmosphere in which the great writers of the various literary periods lived, and describes the chief places of interest for successive generations. The history of the great city, its evolution in size, manners, and customs is traced. There is, in addition, a generous selection from old and new engravings and photographs.

The Outlook (London) says of it "For use of students of English history on its social side the book is of highest possible value. . . . . It has values far transcending mere utility and we do not think we praise it too highly when we count it worthy to rank with the literature it has used so adroitly." *LONDON IN ENGLISH LITERATURE.* By PERCY HOLMES BOYNTON. *$2.50, postpaid $2.65.*

Italian

The study of Italian is growing in colleges, universities, and high schools, and with it the use of the texts in the "University of Chicago Italian Series."

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Forty thousand people in six leading student centers of India—Bombay, Lucknow, Lahore, Calcutta, Rangoon in Burma, and Madras—heard Dr. Gilkey talk on Jesus as our generation sees him. His lectures, now offered in book form, were made possible by the Barrows Foundation, and were inspired by its purpose of presenting "in a friendly, temperate, and conciliatory way, the truths of Christianity to the scholarly and thoughtful people of India."

Dr. Gilkey, one of the most popular preachers in America, speaks with the authentic voice of the younger generation. Here is an unusual commentary on the problem of making the personality of Jesus the constructive force needed in the solution of many modern entanglements.

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Of late years, the analytical investigation of the living organism and its products has made great advances. On the synthetic side, however, progress has been relatively slight. The exact manner in which certain physico-chemical materials combine to produce life remains largely obscure. A valuable contribution to an understanding of the physico-chemical basis of the more general or fundamental properties of living matter is Ralph S. Lillie's *Protoplasmic Action and Nervous Action.* This volume includes not only Dr. Lillie's fundamentally original and significant studies but also a complete summary of previous experimental work in the field.

Much of the volume is concerned with the general physiology of the stimulation processes, and especially with nervous transmission, which is taken as the most interesting type of protoplasmic transmission. For the solution of the problems of transmission, a knowledge of the special conditions under which chemical reactions in protoplasm proceed and influence each other is necessary, and Dr. Lillie investigates the general physical conditions under which these reactions are initiated, accelerated, or retarded. Properties and activities exhibited by protoplasm in all its forms are considered in the light of modern physical and chemical methods of physiological analysis. *PROTOPLASMIC ACTION AND NERVOUS ACTION.* By RALPH S. LILLIE. *$3.00, postpaid $3.10.*

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Elementary Phonetics

A clear, concise explanation of the simple physiological facts necessary to a mastery of the speech-sounds of French is Otto F. Bond's *The Sounds of French.*

Mr. Bond is confident that this manual will help in the introduction of phonetics earlier in the curriculum than is now possible. It is important to note that this manual is for the actual use of the student, a handbook for constant reference. There is a discussion of the theory on which phonetic principles are based, but the greater part of the text is a practical drill manual of thirty-four phonetic exercises. In these the material is given both in normal spelling and phonetic transcription, arranged in parallel columns. The alphabet is that of the Association Phonétique Internationale, without modification.

While the use of *The Sounds of French* is in no way dependent upon phonograph records, it is of interest to know that there is a set of five twelve-inch double-disk records on which are recorded the thirty-four exercises of the manual. These are $12.00, including album and postage. *THE SOUNDS OF FRENCH.* An Elementary Phonetic Manual. By OTTO F. BOND. *$1.25, postpaid $1.35.*

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New Impressions

The continued popularity of the following books has made it necessary for us to bring out new impressions.

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By

ELLIOT R. DOWNING

Scientific study of science teaching has had some valuable results, and these Mr. Downing summarizes in this volume. Here is shown how the growing body of facts about the pedagogy of science, which have been ascertained by the experimental method, may be applied practically to the problems of the science teacher.

This book describes the social and economic background of the science-teaching movement, the history of science teaching in our elementary and secondary schools, present conditions in science teaching, and the aims held.

From this point Mr. Downing takes up the principles of selection and organization of science materials, and actual methods of instruction—by book, lecture-demonstration, and laboratory. There is specific information on notebooks and drawings, field trips, testing results; and suggestions are made for a complete science library in the school.

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THE CITY

Human Behavior in the Urban Environment

By ROBERT E. PARK, E. W. BURGESS, *and* RODERICK D. MCKENZIE

with a bibliography by
LOUIS WIRTH

The city as a social entity has thus far been studied chiefly by writers of fiction, and this book has been written in the belief that the time has come for a more searching and scientific treatment. An investigation of human behavior in the city environment and a study of urban life—its physical organization, its occupations, and its cultures—this volume treats the city as a product of human nature, rather than a bare artificial mechanism.

These titles indicate sympathetic handling of the subject: "The Study of Human Behavior in the Urban Environment," "The Growth of the City," "The Natural History of the Newspaper," "Recreation and Juvenile Delinquency," "The Mind of the Hobo," and "Magic, Mentality, and City Life."

There is a valuable and extensive bibliography by Louis Wirth. This is a volume in the "University of Chicago Studies in Urban Sociology."

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The wonderful old tales from India in *The Panchatantra*, now translated in their entirety for the first time, are fast rivaling the *Arabian Nights*. Lee Wilson Dodd calls the collection "A fine and ancient and humorous and incredibly wise and lovely book." A fourth printing has been ordered. *THE PANCHATANTRA*. Translated by ARTHUR W. RYDER. *$4.00, postpaid $4.15.*

Dr. Gilkey's popularity is attested by the rapid and cordial response that has been paid his new interpretation of the personality of Jesus. Now in its third impression. *JESUS AND OUR GENERATION*. By CHARLES W. GILKEY. *$2.00, postpaid $2.10.*

Edgar J. Goodspeed's recent volume of essays has met with a gratifying critical and popular success. *THINGS SEEN AND HEARD*. By EDGAR J. GOODSPEED. *$2.00, postpaid $2.10.*

The Robinson idea of organizing a book of readings in the field of psychology was a happy one, and their book is being used widely. *READINGS IN GENERAL PSYCHOLOGY*. By E. S. ROBINSON AND FLORENCE RICHARDSON-ROBINSON. *$4.00, postpaid $4.15.*

Edgar J. Goodspeed's famous *American Translation* of the New Testament continues in popularity. There are eight editions now available in different styles and bindings at prices ranging from $1.00 to $5.00.

Wide interest has been shown in the first single volume to state comprehensively the principles that govern cell structure and function. *GENERAL CYTOLOGY*. By ROBERT CHAMBERS, E. G. CONKLIN, E. V. COWDRY, M. H. JACOBS, E. E. JUST, MARGARET LEWIS, W. H. LEWIS, FRANK R. LILLIE, C. E. MCCLUNG, A. P. MATHEWS, T. H. MORGAN, E. B. WILSON, AND RALPH S. LILLIE. *$7.50, postpaid $7.75.*

Hodge and McKinsey's accounting text has given many students a working knowledge of the fundamental principles underlying the gathering, analysis, and interpretation of accounting data. *PRINCIPLES OF ACCOUNTING*. By ALBERT C. HODGE AND J. O. MCKINSEY. *$3.00, postpaid $3.10.*

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For April 1926 and May 1926

The Municipal Budget

Municipal expenditures have been mounting steadily in recent years, and the problem of city administration has become centered upon the need for reducing expenses. City taxes have gone up so much that the attention of the taxpayer is being turned rather forcibly toward any means by which expenditures may be controlled. The device which promises most for the future is the municipal budget. Yet there has been almost no literature on the subject. R. Emmett Taylor, in *Municipal Budget-Making*, investigates and analyzes budgetary practices in the American city, performing a service for the administrator in city government, the student of government, and the taxpayer who is interested in the reduction of taxes.

This book is a complete discussion of the municipal budget, based upon first-hand investigation of budget-making practices in leading American cities, and upon data secured from questionnaires sent out by the Bureau of Municipal Research, New York City. To study actual procedures, Mr. Taylor visited New York, Boston, Syracuse, Cleveland, Detroit, Columbus, Dayton, Cincinnati, Milwaukee, Minneapolis, St. Paul, Portland, San Francisco, Los Angeles, and Denver.

It is important to note that all the recent changes in municipal budget-making in the United States have been incorporated in this book, and that it is entirely up to date. Since it presents a large amount of data upon a subject which has lacked extensive treatment, it is an exceptionally valuable text or reference for students of municipal government.

From his investigation, the author has formulated conclusions respecting the best procedure to follow in making a municipal budget, dependent, of course, upon the size of the city, the form of government, and local restrictions. His ideas on the subject are suggestive aids in the actual planning and preparation of a city budget.

This comprehensive analysis will give impetus to that development of the municipal budget which is so necessary if expenditures and taxes are to be reduced. *MUNICIPAL BUDGET-MAKING.* By R. Emmett Taylor. *$2.50, postpaid $2.60.*

* * *

The Literature of Spain

A picture of Spanish literature as a whole from its beginning in epic and drama to the present generation of writers is presented in George T. Northup's *An Introduction to Spanish Literature.* A work has been greatly needed to introduce the novice to this national literature, in the way that this has been done for French letters. Mr. Northup's volume has received wide commendation for its scholarship and its interest.

Bulletin of Spanish Studies says, "It is superior to any Spanish history of literature in English, not merely for the place which it gives to movements and tendencies, but in the broadness of the spirit in which it is conceived and written. . . . . It is put together carefully, it criticizes sanely, interprets liberally, and teaches understandingly."

Hispania's comment is "It is no small feat to produce a readable history of Spanish literature which will enlighten and interest the novice, and the present volume stands almost alone in its field."

"An admirable presentation that will be welcomed alike by teachers, students, and the general reader" says *The Modern Language Journal*.

The Bookman comments: "His book is a model of compassion . . . . he has managed to make the story of Spanish literature dramatic and interesting." *AN INTRODUCTION TO SPANISH LITERATURE*. By GEORGE T. NORTHUP. *$3.00, postpaid $3.15*.

* * *

Science Teaching

Modern scientific study of science teaching has had some valuable results, and these Elliot R. Downing summarizes in his new book *Teaching Science in the Schools*. Here is shown how the growing body of facts about the pedagogy of science, which have been ascertained by the experimental method, may be applied practically to the problems of the science teacher.

That science should receive more and more attention in our secondary schools is Mr. Downing's belief. In this book, he points out that science has been introduced into the curriculum comparatively recently, that the percentage of students enrolled in science in the secondary schools is greater than in any other subject, and that the increase in such enrolment in the past three decades has also been greater than in any other subject.

Mr. Downing's discussion includes the history of science teaching, the social and economic background of science teaching, present conditions and aims of science teaching in our elementary and secondary schools, tests in science, and science teaching in some European schools.

From this point the author takes up the principles of selection and organization of science materials, and actual methods of instruction—by book, lecture-demonstration, and laboratory. There is specific information on notebooks and drawings, field trips, and testing results, and suggestions are made for a complete science library in the school. Helpful diagrams and graphs show analysis of zoölogy texts for secondary schools, and enrolment in various high-school science subjects in the United States. *TEACHING SCIENCE IN THE SCHOOLS*. By ELLIOT R. DOWNING. *$2.00, postpaid $2.10*.

* * *

New Light on Old Diseases

The science of paleopathology has revealed the fact that diseases have been man's attendants from remote antiquity. What the evidence supplied by paleopathology shows about the origin and evolution of disease has been summarized by Roy L. Moodie in

The Antiquity of Disease. It constructs a remarkable picture of prehistoric pathological conditions.

Germs, Mr. Moodie finds, are among the oldest inhabitants of the earth, although it is only since the Coal Period that they have been disease-producing. It is probable that they were brought to the earth by meteorites from distant planets.

Early surgical operations began in conjunction with the religious practices of sha-

manism of which the sole aim was to liberate evil spirits. From this arose our modern conceptions which have made surgery such an important factor in modern life. In his investigation of the pathology of the ancient Egyptians, Peruvians, and other primitive peoples, Mr. Moodie finds evidences of such a wide variety of maladies that it becomes apparent that modern man need not envy primitive man as far as health is concerned.

This book is sufficiently non-technical to be read by the layman, and it is a valuable work for those interested in medical history, evolution, zoölogy, and geology. *THE ANTIQUITY OF DISEASE*. By Roy L. Moodie. *$1.50, postpaid $1.60.*

What Is Religion?

There is no one statement that will define religion, but attempts at definition have a suggestive value. In the revised edition of *The New Orthodoxy*, Edward Scribner Ames has formulated an interesting group of such definitions. From one point of view Mr. Ames sees religion as "A quest for life in an abyss of death," and from another "it is the mirth of kindred spirits round a glowing fire with the shadows playing over a vacant chair."

Explaining his aim in *The New Orthodoxy* Mr. Ames says, "A lady to whom this book was recommended remarked upon reading its title, 'No, thank you, I do not care to read anything that is orthodox.' Her conception was doubtless much the same as that of a 'liberal' who recently wrote: 'All religions tend toward orthodoxy, that is toward something vital and flowing to a static set of doctrines and a cramped attitude of mind.' This he regards as apostasy from 'the principle of free inquiry into all questions bearing upon the religious life.'

"It is the purpose of this book to insist that there has come into the world a new orthodoxy which is precisely the maintenance of this principle of free inquiry. Orthodoxy means right thinking. . . . . It is true that in the past, religious thought, and also all other kinds of thought, sought too much for static, unchangeable truths. But this is no longer considered right thinking. Science in every field has shown the necessity and the advantage of the open mind. . . . . Consequently the tables are completely turned."

Mr. Ames discusses the attitudes and dramatis personae of the new orthodoxy, the growing Bible, the problems of religious sentiments, sacred literature, religious ideals, and ceremonials of worship. *THE NEW ORTHODOXY*. By Edward Scribner Ames. *$1.50, postpaid $1.60.*

Introductory Sociology

Park and Burgess' widely-used text, *An Introduction to the Science of Sociology*, in its recently revised edition offers a collection of readings selected to define and illustrate the concepts and principles of sociology. An excellent text for an introductory course in sociology, it combines in a single volume the textbook and the necessary reading materials.

Its method of placing concrete material in the students' hands has made possible a clearer presentation of the principles of sociology than has been attained with previous methods. The material is skilfully woven together with introductory and interpretative passages. Each chapter is carefully planned to show the student how to get facts. More than a collection of readings, the book is a systematic treatise, which frees the student from dependence upon library equipment.

Taken from such writers as Thorndike, Sumner, Binet, John Dewey, Georg Simmel, Comte, Spencer, Hobhouse, and Galton, the material represents the investigation and thought of leading figures in sociology and the social sciences. The selections cover the entire field of sociology. In this edition is contained the most extensive and up-to-date sociological bibliography available. New selections have been added to the readings, and revisions in the text have brought it into accord with recent developments in the field.

The discussion shows at once the *structure* of society and the *processes* by which this social structure and the human motives which it embodies grow up, are formed,

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and re-formed under the force of changing conditions. Bringing together the observations and reflections of men who have seen life from different angles, this work will interest not only the student who wants a deeper insight into the nature of society but also the layman who seeks a wider knowledge of human affairs.

"This volume will prove a godsend to teachers of sociology. . . . . This ripe and scholarly work is the last word in perfection in source books for the classroom, and no teacher of sociology can afford to be without it."—PROFESSOR E. A. Ross in *The American Journal of Sociology*.

Emory S. Bogardus, editor of the *Journal of Applied Sociology*, says, "The authors have put sociologists under great obligation by collecting source materials from a wide range of investigation. These materials have been excellently arranged and scientifically interpreted. The book offers a fundamental group of sociological concepts as working tools for the student and investigator alike." *AN INTRODUCTION TO THE SCIENCE OF SOCIOLOGY*. (Revised Edition.) By ROBERT E. PARK and ERNEST W. BURGESS. *1,000 pages, $4.50, postpaid $4.70.*

* * *

Thomas Hardy

In making a specialized study of Thomas Hardy's novels exclusively with reference to their technique, Joseph Warren Beach leads the student of literature along paths of technical study long employed with the short story and the drama, but neglected in the case of the novel. *The Technique of Thomas Hardy* is not only a guide to the study of the last of the great Victorian masters, but also throws light upon the general subject of the technique of the novel.

Mr. Beach takes up in succession fourteen Hardy novels, showing the prevailing method of each, and the progress of the novelist's power from mere artifice to genuine art. The development of Hardy's art is traced from the Collins-like ingenuity of *Desperate Remedies*, through the introduction of irony in *A Pair of Blue Eyes*, to a full realization of the value of setting in *Far from the Madding Crowd*.

Mr. Beach raises pertinent questions of Hardy's real attitude toward his art, of the

ideals he held for a novel, and the extent to which he was willing to sacrifice these ideals for the sake of popularity. *The Nation* says of the book: "Mr. Beach's book is intelligent and searching. It fetches up from the depths of your memory all that is lodged there relating to Thomas Hardy." *THE TECHNIQUE OF THOMAS HARDY.* By JOSEPH WARREN BEACH. *$2.50, postpaid $2.60.*

* * *

Francesca da Rimini

Pellico's friend, Ugo Foscolo, advised him to throw the manuscript of *Francesca da Rimini* in the fire, and not terrify the living by recalling Dante's spirits from hell. But Pellico resisted the suggestion, and his became one of the best-known versions of the Francesca story.

Kenneth McKenzie has edited this version, and has included in the same texts extensive selections from Pellico's *Le mie prigioni*, which is perhaps the most famous bit of autobiographical narrative written in nineteenth-century Italy. Its style, patriotic spirit, and fine personal quality all commend it to the student of Italian. The slightly old-fashioned coloring of Pellico's language makes these works a particularly good introduction to the reading of classic Italian literature. *PELLICO'S LE MIE PRIGIONI AND FRANCESCA DA RIMINI.* Edited with Introduction, notes, and vocabulary by KENNETH MCKENZIE. *Illustrated, $1.25, postpaid $1.35.*

* * *

Some Comments

The following sentences about Morrison's *The Practice of Teaching in the Secondary School* are taken from a review by Dr. Winfred E. Garrison in the April 1 *Christian Century*.

"I venture the opinion that it should also have a very wide reading among parents, ministers, students of religious education, and others who have reason to need to understand the educational process even though they may not spend their days behind a teacher's desk. For while the title gives promise of a practical treatment of specific problems of high-school teaching—a promise which is richly fulfilled—the implications touching the meaning of the

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whole educational process are as important for intelligent people generally as the technical suggestions are to members of the profession.

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". . . . I have no fear that teachers will not have it brought to their attention, but I am solicitous that it shall not be overlooked by the many others who ought to read it but to whom the title will suggest something too exclusively technical. . . . ."

"I am certain that teachers of long experience who may, at times, feel that they are not accomplishing all that they would wish, as well as beginners in the profession, will find this book full of stimulating ideas and suggestions. Three years of experimentation with these principles in the teaching of American history have convinced me that Dr. Morrison has developed a theory and practice of education that is not only scientifically sound in theory but which really 'educates' in practice."—D. C. BAILEY, Lyons Township High School, LaGrange, Illinois.

"In *The Practice of Teaching* Professor Morrison clears away many confusing and contradictory problems of education when he enforces and illustrates the principle that all true teaching must enable the pupil to make thorough, effective, and permanent adaptations to the fundamental situations which are met in successful living. For three years I have used his principles with increasing satisfaction in my teaching of general science."—CLIFFORD R. MADDOX, Whiting Junior High School, Whiting, Indiana.

"If there are those who doubt the feasibility of a general technique of teaching for secondary schools let them read Morrison. In fact the mastery technique has been successfully used on even the university level in my own classes."—F. DEAN MCCLUSKY, Director of the Division of Educational Reference, Purdue University, Lafayette, Indiana. *THE PRACTICE OF TEACHING IN THE SECONDARY SCHOOL.* By HENRY C. MORRISON. *661 pages, $4.00, postpaid $4.15.*

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Pehlvy, or Pehlevi (Ancient Persian version) by Barzuhey, physician of Nushirvan (6th century A.D.) with additions and introduction, and entitled *Fables of Bidpai*.

German translation direct from Sanskrit by Benfey (1859).

Arabic, by Abdallah Ibn Almokaffa (8th century), entitled *Calilah va Dimna* (names of two interlocutors), ed. Silvestre de Sacy, *Calila et Dimnah ou Fables de Bidpai* (1816).

Persian, by 'Abou'l Maali Nasr Allah (12th century).

Spanish (Lost MS) used by Raimond of Béziers in his Latin version (*ca.* 1300 A.D).

Second Persian, recast in more modern and popular form by Hosian baez Caschefi (*ca.* 1530 A.D.), entitled *Anvari Sohaili* or *Lights of Canopus* (the emir Sohaili being compared to the favorable star Canopus [Sohail]).

Third Persian by Abou'l Fazl (1621 A.D.), *Eyari Danisch*, or *Touchstone of Knowledge*.

Turkish. A translation of above by Ali Tchelebi (*ca.* 1540), dedicated to Suleyman the Magnificent, entitled *Homayaoun-Nameh* or *Royal Book*.

Modern French by "David of Ispahan" Gaulmin (1595–1665) entitled *Livres des Rois*.

Second English, *Instructive Fables of Pilpay* (16—, 7th ed., 1775.)

Third English, from Arabic ed. of Silvestre de Sacy, by Knatchbull (1919).

Fourth English version from Second Persian by Eastwick (1854).

Fifth English version made by Keith Falconer, 1885, from.....

Syriac version, whether made from Arabic or uncertain, ed. W. Wright (1884).

FAMILY TREE

Tibetan folklore, old Slavonic stories, and old Syriac. Some writers believe that the tales are the foundation of our modern short story.

The Family Tree here given is very incomplete, for only the more significant, available editions and translations are named. Numerous fragments and corrupted versions suggest that translations were made at various times for the pleasure of a patron and his friends. It is obvious from the sale of the most recent edition that the ancient tales are popular today in one version or another, though few realize their age. *THE PANCHATANTRA.* Translated from the Sanskrit by ARTHUR W. RYDER. *$4.00, postpaid $4.15. GOLD'S GLOOM.* Tales from *The Panchatantra.* Translated by ARTHUR W. RYDER. *$2.00, postpaid $2.10.*

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morphosed into "Sandebar."

eek b by John of Capua (13th century), entitled
th (*ca.* *storium Vitae Humanae.* (First printed 1480.)
Puntos

Old French version by "Dam Jehans" of the abbey of Hauteselve (13th century), entitled *Li romans de Dolopathos.* See Brunet and Montaiglon's preface to Jannet's Elzevirian edition.

1 A.D. an, Doni: *Filosofia Morale.* (Printed 1552.)
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Best Sanskrit text by Johannes Hertel—Harvard Oriental Series (1908).

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Current Economic Problems, edited by Walton H. Hamilton, has for several years been the outstanding book in its field. To take account of the swiftly marching events of developing industrialism, and to bring into the discussion contemporary questions of economic importance, Mr. Hamilton has revised the text so thoroughly that it is now practically new.

Mr. Hamilton has designed this book for use as a text in courses in current economic problems, whether such courses precede or follow the course in principles, or as a text in general courses in economics. Through a series of readings in the control of industrial development is presented a general view of the entire field. Such problems as those of the business cycle, railway regulation, population, and unionism are taken up in turn, given adequate historical setting, and full consideration of their relation to the structure of industrial society. The new edition contains readings that bring the problems up to date: there is, for example, material on recent legislation about railroads, and on new aspects of the trust problem.

Other revisions are the shifting of emphasis to aspects of problems that are just now receiving much attention, and the omission of out-of-date material. Older statements have been replaced with better ones, and the literature of economics of recent years has been culled for new material.

"A Series of Readings in the Control of Industrial Development" might well be the subtitle of this book. It is based upon the theory that our society is a developing one, with interdependent institutions; that current problems rest upon immutable human nature, an individualistic scheme of social arrangements, and world-wide machine industry; and that conscious attention to these problems is the means through which industrial development is to be controlled. Every variety of economic opinion is represented. Yet, out of the whole comes a vivid, unified impression of the course of economic life. To give a perspective of economic problems, to reveal the outstanding features of economic organization—this is the chief purpose of the volume. It translates current economic problems into the problem of the control of industry. *CURRENT ECONOMIC PROBLEMS*. Edited by WALTON H. HAMILTON. (Revised Edition.) *$4.00, postpaid $4.25.*

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Eyari Danisch, or *Touchstone of Knowl*

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nd ed. Jaco

Turkish. A translation of above by Ali Tchelebi (*ca.* 1540), dedicated to Suleyman the Magnificent, entitled *Homayaoun-Nanieh* or *Royal Book*.

Modern French by "David of Ispah
Gaulmin (1595–1665) entitled *Livre des Rois*.

Second English, *Instructive Fables of P*
(16—, 7th ed., 1775.)

Third English, from Arabic ed. of Silvestre de Sacy, by Knatchbull (1919).

Fourth English version from Second Persian by Eastwick (1854).

Fifth English version made by Keith Falconer, 1885, from.....

Syriac version, whether made from Ar
uncertain, ed. W Wright (1884).

TA FAMILY TREE

Tibetan folklore, old Slavonic stories, and old Syriac. Some writers believe that the tales are the foundation of our modern short story.

The Family Tree here given is very incomplete, for only the more significant, available editions and translations are named. Numerous fragments and corrupted versions suggest that translations were made at various times for the pleasure of a patron and his friends. It is obvious from the sale of the most recent edition that the ancient tales are popular today in one version or another, though few realize their age. *THE PANCHATANTRA.* Translated from the Sanskrit by ARTHUR W. RYDER. *$4.00, postpaid $4.15. GOLD'S GLOOM.* Tales from *The Panchatantra.* Translated by ARTHUR W. RYDER. *$2.00, postpaid $2.10.*

al Sans known). The
ha-Tantra," ed. Kosen-
(Bonn, text, is said to
second

Sanskrit complete English translation direct from San-
by Arthur W. Ryder (1925).

ew, attributed to Rabbi Joel, containing two
ers not in *Calilah va Dimna.* "Bidpai" is here
morphosed into "Sandebar."

Greek by John of Capua (13th century), entitled
Seth *storium Vitae Humanae.* (First printed 1480.)
V. Pe

Old French version by "Dam Jehans" of the abbey of Hauteselve (13th century), entitled *Li romans de Dolopathos.* See Brunet and Montaiglon's preface to Jannet's Elzevirian edition.

(1621 An, Doni: *Filosofia Morale.* (Printed 1552.)
Knowle

ish by Sir E. North. Used by Shakespere. Re-
ed. Jacobs (1880).

Ispaha
Livres

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Best Sanskrit text by Johannes Hertel—Harvard Oriental Series (1908).

REVISED EDITION

Evolution, Genetics, and Eugenics

By

HORATIO HACKETT NEWMAN

Attendance at the Dayton trial as a witness for the defence has enabled Professor Newman to describe and interpret it in this new revised edition of his text. He brings the knowledge of the evolutionary biologist to bear upon the present anti-evolution campaign in the United States, and studies it historically, giving the facts about evolution needed for an intelligent attitude toward the controversies.

The discussion of mutation, linkage and crossing-over, inheritance of acquired characteristics, eugenics, and other topics has been brought completely up to date. Here in a single volume is a comprehensive treatment of all the important phases of evolutionary biology that takes account of recent developments.

Original material by Professor Newman weaves together a well-balanced selection of excerpts from such writers as Darwin, Weismann, Romanes, and Castle. This is an excellent text for survey courses in evolutionary biology and a clear treatment for the general reader.

$3.50, postpaid $3.70

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Current Economic Problems, edited by Walton H. Hamilton, has for several years been the outstanding book in its field. To take account of the swiftly marching events of developing industrialism, and to bring into the discussion contemporary questions of economic importance, Mr. Hamilton has revised the text so thoroughly that it is now practically new.

Mr. Hamilton has designed this book for use as a text in courses in current economic problems, whether such courses precede or follow the course in principles, or as a text in general courses in economics. Through a series of readings in the control of industrial development is presented a general view of the entire field. Such problems as those of the business cycle, railway regulation, population, and unionism are taken up in turn, given adequate historical setting, and full consideration of their relation to the structure of industrial society. The new edition contains readings that bring the problems up to date: there is, for example, material on recent legislation about railroads, and on new aspects of the trust problem.

Other revisions are the shifting of emphasis to aspects of problems that are just now receiving much attention, and the omission of out-of-date material. Older statements have been replaced with better ones, and the literature of economics of recent years has been culled for new material.

"A Series of Readings in the Control of Industrial Development" might well be the subtitle of this book. It is based upon the theory that our society is a developing one, with interdependent institutions; that current problems rest upon immutable human nature, an individualistic scheme of social arrangements, and world-wide machine industry; and that conscious attention to these problems is the means through which industrial development is to be controlled. Every variety of economic opinion is represented. Yet, out of the whole comes a vivid, unified impression of the course of economic life. To give a perspective of economic problems, to reveal the outstanding features of economic organization—this is the chief purpose of the volume. It translates current economic problems into the problem of the control of industry. *CURRENT ECONOMIC PROBLEMS*. Edited by WALTON H. HAMILTON. (Revised Edition.) *$4.00, postpaid $4.25.*

The PRESS IMPRINT

For August and September, 1926

Brains of Rats and Men

That man's brain has been slowly developed from other kinds of animal brain structures, that human behavior patterns and the noblest human faculties are functions of man's peculiar protoplasmic organization—to many these still seem difficult statements to accept. Their truth, however, is further demonstrated by C. Judson Herrick in *Brains of Rats and Men*, his new book on the origin and biological significance of the cerebral cortex. It is a volume that belongs to that rare class of scientific works of genuine literary merit, in which Mr. Herrick traces the evolution of this amazingly complex organ from fishes to men, and follows step by step the elaboration of its functions.

Objective behavior and subjective experience are here reformulated in biological terms. Mr. Herrick demonstrates incisively that the entire intellectual, emotional, and moral life of mankind can be explored as biological functions without loss of their supreme values as distinctively human attributes and without passing outside the realm of natural laws.

Others have tried to read human faculties backward into the lower animals. Mr. Herrick reverses the order and, beginning with the simplest structures prophetic of cerebral cortex, he reads this history through to its culmination in man. He outlines also the development of the thalamus and corpus striatum and their functional relations with the cortex.

He turns then to the mechanism of learning, centering the discussion about the brains of rats and men, the two species of mammals whose behavior patterns have been studied most intensively under conditions of laboratory control. Recent experiments upon learning in rats are summarized.

In considering the transition from brute to man, Mr. Herrick calls attention to the fact that the brain of man is more than twice as heavy as that of an ape of equal body weight and that this increase is chiefly in the cerebral cortex. The complexity of the internal texture of the human cortex surpasses that of an ape in still larger measure.

Mr. Herrick emphasizes the unscientific character of the oversimplification of human behavior so popular in some psychological circles. He believes that human nature cannot be understood without recognizing that its patterns of behavior are very different from those of rats and monkeys, and that conscious experience is an essential component of these human behavior patterns in their biological aspects.

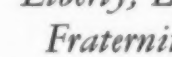
Approaching the problems of human nature from the biological side and with biological technique, the author works out a common ground upon which objective psychology and introspective psychology may meet without sacrificing what is good in either method. He has demonstrated that, without transgressing the boundaries of biological science, we can set in their places objective behavior in all its manifestations: affect, impulse, volition, and the whole intellectual and moral life together with the structural mechanisms employed.

The concluding chapters have a special significance for psychology and education, since they throw light upon such problems as the subconscious, complexes, habit, vital reserves, experience, association, will, and the relations of mind and body.

This account of the cerebral cortex, its evolution and its functions, by one of America's foremost neurologists touches upon problems that are fundamental to all the sciences that take living things, and man in particular, as their province: biology, psychology, anthropology, the social sciences, education, medicine. *BRAINS OF RATS AND MEN.* By C. JUDSON HERRICK. *$3.00, postpaid $3.15.*

"Liberty, Equality, Fraternity"

Beyond all other ideas of government, democracy means not merely a governmental mechanism, but a way of life. The social philosopher who thus broadly conceives it must turn to the most general interests of mankind. Thomas Vernor Smith, in his new book *The Democratic Way of Life*, re-endows "Liberty, Equality, Fraternity"—worn slogans of a goal that has never been reached—with some of the spirit of the days when they were magic words; and makes a brilliant commentary upon the questions of humanizing work, the proper use of leisure, religion in a democracy, birth control, and democratic leadership.



To make clear the abiding real content of the democratic trinity of ideals, Mr. Smith inquires into these goals as they stand today. He looks upon liberty as fundamental, a natural end for life, and would restrict it only for the sake of fraternity. He admits that liberty is neither more nor less than doing as one pleases, but believes that through proper education men may please more and more to act fraternally.

Fraternity, Mr. Smith holds to be a natural and ethical end for man. It is, in his view, the basis of religion, and the function of religion in a democracy is to foster brotherhood within the group and universal brotherhood.

What can equality as an ideal mean in the light of the present-day facts? Mr. Smith's equalitarian ideal means fundamentally that whatever objects or activities are regarded as good must be admitted to be as good when experienced by one person as when experienced by another. He sees in war and industrial autocracy the arch-enemies of equality, and in the cessation of wholesale hostility, the development of industrial democracy, necessary measures for the attainment of the equality ideal.

Bertrand Russell has expressed the belief that with present technology, the four-hour day awaits only the will to have it. Regarding such optimism as at best prophetic of a distant time, Mr. Smith, in considering work and leisure, prefers to place emphasis upon the humanizing of work, and to give up the tenaciously held idea that the good life is to be found exclusively in leisure. The supreme moral task of the hour, in Mr. Smith's view, is in banishing drudgery and monotony, and investing otherwise unpleasant work with meaning.

What kind of leadership is needed in a democracy? Mr. Smith rejects the conception of leadership of prestige and authority inherited from monarchies, and replaces it with the new conception of leadership suggested by science. The new type of leader is a leader by virtue of knowledge, and his function is to point, not to order. Science having discredited the spectacular and omniscient type of leader, democracy must be judged not by its ability to produce a few "master-leaders," but by its ability to make every citizen a creative leader in some enterprise.

Mr. Smith has brought to these principles of democracy, upon which so much enthusiasm has been lavished and over which so much disappointment has been felt, an undeniable tinge of modernity. He has formulated a democratic credo, a profession of the social faith of a modern man. *THE DEMOCRATIC WAY OF LIFE.* By THOMAS VERNOR SMITH. *$1.75, postpaid $1.85.*

A New French Grammar

One hears it frequently said that of the making of French grammars there is no end but that the French grammar has yet to be written. That is to say a new one may legitimately make its bow without regarding too much the weight of its predecessors.

The new *Introduction to the Study of French* by Otto F. Bond will make a place for itself among French texts where the rapid attainment of the ability to read and understand French is the end most desired. Teachers who find that the prolonged syntactical study and delayed actual reading made necessary by most grammars is somewhat boring both to instructor and student will welcome this grammar which equips the student in twenty lessons to read interesting material.

It is a "comprehension" grammar, brief, thorough, and intensive, and written from the point of view of the student struggling with the difficulties of the printed page and the spoken word and desiring a mastery of these problems early in the course.

The "reading method" upon which this book is based has been in use in the Junior College of the University of Chicago for five years with remarkable success. It has led to an average reading of 1,500 to 1,800 pages in the first year of instruction in French.

In an article in the *Modern Language Journal* for April, 1926, Mr. Bond says: "If Mary White wants to read *Le Petit Chose* or *Abeille* before she can order from a French menu or juggle a pair of partitive constructions in a negative sentence, why not let her do it? She cannot fail to get some good out of the performance even if she doesn't get all the story with full literary appreciation. Suppression of her desire to read cannot be expected to heighten her interest in partitive constructions!"

In preparing a text which concentrates on the problem of getting the student to the point where he can follow his natural interest in reading, Mr. Bond has performed a valuable service for instructors whether or not they agree with him that the primary aim of the junior college course should be the development of reading ability. The text may be followed by the direct method or the grammar-translation method, and its value as a starting-point for the course and a means for creating interest in the course is not lessened.

An Introduction to the Study of French is one of the new "University of Chicago Junior College Series" designed through specially constructed texts to accomplish efficiently in one year the purpose of elementary modern-language instruction at the college level. Another volume in the series, already published, is *The Sounds of French* by Otto F. Bond, a graded, intensive, phonetic drill manual, equipped with analytical exercises. In December, a third volume in the series, *Premières Lectures*, will appear. It is a first reader to be begun with the twelfth recitation of the course and to lead to extensive (outside) reading by the twentieth. *AN INTRODUCTION TO THE STUDY OF FRENCH.* By Otto F. Bond. *$1.00, postpaid $1.10. THE SOUNDS OF FRENCH.* By Otto F. Bond. *$1.25, postpaid $1.35.*

* * *

For the Bacteriology Laboratory

Instructors arranging courses in bacteriology, serology, and immunology will find helpful the new *Laboratory Outlines in Bacteriology and Immunology* by John F. Norton and I. S. Falk. For students of these subjects it will serve as a handbook and guide in the laboratory. The material consists of exercises which are designed to acquaint the student with a variety of the best methods, to give him practice in working with different groups of bacteria, and to illustrate immunologic phenomena.

The manual is a guide to the preparation of media, to microscopic examination, and to work with bacteria from the respiratory tract, miscellaneous and higher bacteria, anaerobes, toxins, and antitoxins. There are exercises on vaccine preparation, Wassermann reactions, tuberculin reactions, and examination of milk.

Goode Base Maps and Graphs

Prepared by

J. PAUL GOODE

Professor of Geography in the University of Chicago

The Goode outline maps are widely used for work in research, in applied science, and in every grade from the common school to the university. The quality of the drawing is superior; the maps are lithographed on high-grade paper which takes pencil, ink, or water color, with perfect results; and are designed for insertion in a standard notebook cover.

A new map of the world has been done on Mr. Goode's homolosine equal area projection, and is now being used by the United States Department of Commerce in its publications. This new projection gives land areas exactly true, and involves less distortion in shape than any other projection thus far developed.

The maps come in five sizes from one and one-half to sixty cents each.

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These outlines should be in the hands of the instructor and of each member of the class. The manual is a flexible one in its arrangement and can easily be adapted to the character of the course offered, and to the amount of time available for laboratory work. There is material here for a full year's work, but it is so arranged that the manual is equally useful for shorter courses. *LABORATORY OUTLINES FOR COURSES IN BACTERIOLOGY AND IMMUNOLOGY*. By JOHN F. NORTON and I. S. FALK. *$2.00, postpaid $2.10.*

* * *

The Origins of the Gospels

Ernest DeWitt Burton continued during his last years the researches concerning the origins of the Four Gospels which had been the basis of his valued *Short Introduction to the Gospels*. He made further investigations regarding the dates of the Synoptic Gospels, and approached the Fourth Gospel from a new point of view, applying the method of source criticism that he had already used with conspicuous success for the Synoptic Gospels.

These significant advances have been incorporated by Harold R. Willoughby in a new revision of the volume which brings to biblical students Dr. Burton's final conclusions. Two important sections of fresh material found in Dr. Burton's files have been added. The first renders an exceptional judgment regarding the dates of the Synoptic Gospels. The second outlines a unique theory concerning the composition of the Fourth Gospel which illuminates the Johannine depiction of Jesus.

This authoritative revision places before students of the gospels those facts concerning the purpose and point of view which are most necessary for an intelligent reading and study of them. *A SHORT INTRODUCTION TO THE GOSPELS*. By ERNEST D. BURTON and HAROLD R. WILLOUGHBY. *$1.75, postpaid $1.85.*

* * *

World-Literature

Richard Green Moulton spent his life in the study and interpretation of world-literature and the culmination of his work is *The Modern Study of Literature*. It is a

book that embodies his familiarity with literature in all its forms, and his extraordinary ability to act as a guide to others in the development of literary appreciation. In it he reached the final formulation of a complete philosophy of literature, and applied it to the greatest literary masterpieces.

Moulton's method of interpretation regarded all literatures as one, and dealt with ancient, medieval, and modern, whether of England or of the Continent, as different manifestations of a single impulse. To him the great mistake of modern literary study was its failure to recognize the unity of all literature. In *The Modern Study of Literature* he supplied the comprehensive synthesis which he thought to be the great need of modern criticism.

His method was that of inductive observation, and he looked upon literary growth as a matter of evolution as definite as development in the physical world. Moulton's life as an interpreter of literature is summed up in this, his greatest work—a volume that every student and lover of world-literature should read. *THE MODERN STUDY OF LITERATURE.* By RICHARD GREEN MOULTON. *$3.00, postpaid $3.15.*

* * *

Risk

A risk of loss exists in nearly every business undertaking, and it is therefore of great importance to the student to understand this phase of business life. For several years the School of Commerce and Administration of the University of Chicago has offered a course which analyzes the element of risk in business, and gives an understanding of its practical consequences as well as a knowledge of the agencies that serve to counteract its effects. The material of this course is contained in *Risk and Risk-Bearing*, in which Mr. Hardy isolates and explains the influence of uncertainty in economic life.

In addition to a study of the sources and effects of risk, Mr. Hardy makes a detailed examination of the methods employed to eliminate, transfer, and reduce uncertainty. Business forecasting with special reference to the business cycle, investment analysis, and the operation of the speculative market are given detailed considera-

Source Book for the Economic Geography of North America

By

CHARLES C. COLBY

From the viewpoint of industrial opportunity, this book presents a survey of the various sections of the continent. In the selection of material, Mr. Colby has been governed by the belief that there is a direct relation between the environment and the economic activities of a region. The book makes available to the busy teacher data which has been accessible only in widely-scattered sources.

Canadian, Mexican, and United States government publications have contributed to this collection, as well as a great variety of magazine articles. From Mexico to Alaska, the discussion progresses, bringing out the most important facts about natural resources, physical characteristics, and economic problems. With maps, diagrams, and statistical tables from government reports, and a wide range of reading materials, this volume is not only a text for college use, but a reference work for the layman.

$3.00, postpaid $3.10

THE UNIVERSITY OF CHICAGO PRESS

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The Origin of the Earth

By

THOMAS C. CHAMBERLIN

The story of a research, the steps and methods of an inquiry, and the exposition of a new theory of the formation of the earth are woven together in this volume. The inquiry started two decades ago in the study of the glacial problem; it led through the enigmas of earlier climatic states, and created grave doubts as to the truth of the conception of a once molten globe enveloped in great, hot atmospheres.

Mr. Chamberlin discusses the disclosures that led to the rejection, one after another, of older views of the origin of the earth, including the nebular hypothesis of Laplace. He describes the futile attempts to emend these theories or to build others on the same foundations, and, finally, traces the steps in the construction of his own, radically new view, based on a dynamic foundation.

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tion. The theory of "hedging" is fully explained, and there is comprehensive discussion of fire, life, property, accident, and casualty insurance.

This book gives the student a connected treatment of the elements of uncertainty in business, subjects that have been customarily touched upon as unrelated topics in various courses. *RISK AND RISK-BEARING*. By CHARLES O. HARDY. *$3.50, postpaid $3.60.*

The most flexible of textbook forms, the collection of readings, is used in a companion volume, *Readings in Risk and Risk-Bearing*, to cover thoroughly the element of risk in business, as seen through the eyes, not of one man, but of many specialists. This volume provides in convenient form supplementary reading for college classes in the subject, particularly where Mr. Hardy's *Risk and Risk-Bearing* is the principal text. The organization of the two books is substantially the same, the chapters in the supplementary volume corresponding in title and subject to those of the text itself. Divergent points of view are represented and those portions of the main text are supplemented most fully which experience has shown to be most in need of additional material.

There are readings on the cost of risk, ways of dealing with it, the business cycle, business forecasting, risk and the management of capital, securities and speculation, hedging, the various classes of insurance, guaranty and suretyship, the risks of labor, and the social aspects of risk-bearing.

The sections on insurance comprise nearly half the volume, and the discussion will give the student a knowledge of the questions that are interesting the insurance world. *READINGS IN RISK AND RISK-BEARING*. By CHARLES O. HARDY. *$3.50, postpaid $3.60.*

The new *Catalogue* of the University of Chicago Press is ready for distribution and will be mailed to all applicants. It is a complete list of the books—nearly a thousand of them—published by the Press, with special emphasis on the new books that are being introduced this fall.

Write for a copy of this book about books.

The PRESS IMPRINT

November and December 1926

The World and Man

The advance of modern science has revealed a vast store of fascinating facts about the universe in which we live. More discoveries have been made in nearly every branch of science in the past two or three decades than in all the previous history of mankind. Scientists have disclosed a world of the infinitely small in electrons, atoms, and molecules; and of the enormously large in giant suns and galaxies of stars, billions of miles distant. They have looked back millions of years to the origins of worlds, and have traced their history through the geological ages to the present. Myriads of plants and animals have been studied, from the lowliest bacteria and protozoa up to man. Minute investigation of man himself—his origin, the wonders of his body, the development of his intelligence—has yielded astonishing facts. Inanimate matter has revealed marvelous secrets to the modern chemist. The physicist has explained the forces we see about us every day, and the biologist is seeking to explain the very secret of life itself.

To help the inquiring reader in his efforts to keep up with the procession of modern science, sixteen members of the Faculty of the University of Chicago have written *The Nature of the World and of Man*, which E. E. Slosson describes as a book for "those who have not been to college and those who have."

These men, specialists in their fields, are the authors: Forest Ray Moulton, Rollin T. Chamberlin, J Harlen Bretz, Harvey B. Lemon, Julius Stieglitz, Horatio Hackett Newman (the editor), Edwin Oakes Jordan, Merle C. Coulter, Henry Chandler Cowles, Warder C. Allee, Alfred S. Romer, Fay-Cooper Cole, Elliot R. Downing, George W. Bartelmez, Anton J. Carlson, and Charles Hubbard Judd.

Beginning with the outstanding facts about the solar system, each of the sixteen authors has described that phase of development with which he is most familiar: the origin and early stages of the earth; geological processes and the earth's history; the nature of energy and matter; bacteria and their origin; evolution of the plant kingdom, the vertebrates, and the invertebrates; interactions between plants and their environment; the coming of man; organic evolution and the origin of life; human inheritance; structure of man; the living process; and mind in evolution.

Throughout, the authors have emphasized the conception of science as a glowing, living thing inextricably bound up with every human life. With all its multiplicity of authorship, the book has (in the words of the *Chicago Tribune*) "taken on the unity, the coherence, the march of one great epic poem."

Stuart Pratt Sherman said not long ago: "I have a strong impression that our 'average' American is waking up, responding to the new emphasis on 'adult education,' becoming infatuated with the idea of having his education go on as long as he does. He has got wind of the secret that in all the fields of knowledge enormous changes and advances have been made in the last twenty-five years and are still being made at this present hour. His sporting desire to keep up with his times grows keener and the range of his curiosity will soon be encyclopedic."

The popularity of *The Nature of the World and of Man* is evidence of the awakening of the adult public to the possibilities of

further education. For the reader outside the universities the book is a guide to the world of contemporary science; it enables him to form a conception of how the earth came to be, what its place is in the vast physical universe, how life originated; it gives him glimpses of the monsters of early ages; shows him how Cro-Magnon man lived, how atoms are held together in a molecule, how invisible throngs of bacteria surround us, how life came from the sea to the land, why insanity is increasing, how speech developed, how hormones regulate bodily processes. . . . .

The Nature of the World and of Man contains the subject matter of a "survey course" given each year by its authors to a selected group of beginning students at the University of Chicago. The success of the experiment upon which it is based suggests a wide use of this text in similar courses in other institutions to give the beginner a preliminary view of the surrounding world and of his possible function in it.

In this day of increasing specialization and a confusingly large body of human knowledge, orientation toward the more general aspects of the world and of man is a necessity. In the belief of the authors of this text, orientation may best begin with a presentation of what modern science holds as truth. They have therefore attempted to give the student that acquaintance with the general outlines of scientific thought which is the ideal point of departure for his entire intellectual development, and which alone affords him the proper perspective on the world of modern thought. More specialized courses in thinking, man in society, or the arts, may well follow, but this course, being more informational, more inclusive, and easier for the beginner should be the point of departure. *THE NATURE OF THE WORLD AND OF MAN*. By Sixteen Members of the Faculty of the University of Chicago. *$4.00, postpaid $4.15.*

Current American Prose

In a volume of provocative essays, *The Outlook for American Prose*, Joseph Warren Beach searches the current prose of reflection, reminiscence, criticism, and social commentary for auguries of a first-rate style. He judges as stylists the American prose artists who are now in the public eye. Timely and incisive comment from this candid and erudite observer will be not unwelcome to readers who have become aware of the development of American prose style in such books as *Troubadour, Straws and Prayer-Books*, and *A Story-Teller's Story*.

A professed eclectic, and adherent of no particular school or tendency, Mr. Beach seeks the perfect style wherever it may be found. Looking about for American writers of cultivated philosophical prose to compare with Bertrand Russell and Havelock Ellis; biographers to rank with Lytton Strachey; newspaper essayists to place beside Chesterton; and critics as stimulating as Shaw, he advances a gratifying number of claimants to distinction. In Sherwood Anderson, James Branch Cabell, H. L. Mencken, Stuart Pratt Sherman, Paul Rosenfeld, Simeon Strunsky, and Alfred Kreymborg, Mr. Beach finds the most hopeful signs of a distinguished prose art in America, and whether or not you agree with him, you will have to reckon with his arresting dicta on the luminaries of the day.

"Old fashioned or new fashioned, what we want is something first rate," says Mr. Beach. His regard for stylistic perfection leads him to protest against the incoherence of Hergesheimer; the lack of precision in John Dewey; the naïveté of Dreiser; the scientific jargon of Van Wyck Brooks; and the affectations of Van Vechten. Sentimental violence and overuse of such words as "devastating" and "poignant" are charged against Ben Hecht, Hutchinson, Walpole, and Hergesheimer.

SHERWOOD ANDERSON

—"*A prose-writer who dares to use the devices of the poet.*"

Mr. Beach finds Gamaliel Bradford too serious minded and turns for lightness of touch to Strunsky and Morley. In Anderson, Cabell, Mencken, and Sherman, he finds the supreme qualities of flavor and individuality, gusto, and precision. Kreymborg's style is "uniformly graceful, delicately tinted."

VAN VECHTEN

—"*Baedeker of the intelligentsia.*"

Mr. Beach has put to good use a conception of the genuine critical spirit characterized by candor and tolerance. He admits that he has been denied that arrogance which enables a critic to tell at a glance whether or not a writer is one of the immortals. First-rate prose he finds most frequently in the unpretentious styles that slip in between rigid categories.

You will want to read this book for the vigor of its outlook upon American prose and for its timely comment on some of the most interesting figures in modern literature.

H. L. Mencken says in the *American Mercury:* "This is perhaps the first book, written by an American, in which precept is backed up by practice. Mr. Beach writes very effectively, and has much of interest to say. His judgments on the writing of Dreiser, Anderson, Van Vechten and other living Americans are well-informed and plausible." *THE OUTLOOK FOR AMERICAN PROSE.* By JOSEPH WARREN BEACH. *$2.50, postpaid $2.60.*

* * *

New Version of the Psalms

For a long time we have needed a translation of the Book of Psalms into the language of our day—a translation that would give the modern reader new insight into the classical rendering of the King James Version, and enable him to see in the Psalms the meaning they originally had. Such a translation is the new version by J. M. Powis Smith, which removes the stumbling-blocks of a centuries-old vocabulary, and divests the verses of unwarranted meanings which a succession of early translators read into them. This version is based upon the official Hebrew text, corrected and emended in accordance with the findings of present-day scholarship.

Dr. Smith expresses at the outset his admiration for the King James Version of the Psalms as "a masterpiece of English literature, unrivalled in beauty," and disclaims any attempt to supplant it with his own version. His purpose is rather to express, as completely and as accurately as the limitations of language permit, the thought and feeling of the original; and to incorporate the scholarship of recent decades, with its more thoroughgoing text-critical method and improved philological results. His aim has been at all times to create a clear and uncorrupted version in which the reader of today will be able to see unhampered the beauties and true meaning of the world's greatest hymnbook.

This translation is intended for the public rather than for technical study; it is not, however, an attempt to bring the Psalms down to the level of the mythical "man on the street." The Psalms are here reproduced in a language and style befitting their spirit and content.

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By W. L. EIKENBERRY

Head of the Department of Science State Normal School, East Stroudsburg, Pennsylvania

In this book the author discusses the necessity of the creation of a technique of presentation that will properly diffuse scientific knowledge. Detailed consideration is given to experiments in the instruction of the public in which the character of the general science movement, as well as its connection with the past history of science teaching, its relation to the established sciences, and its place in the new science of education, is depicted.

This volume is not a manual of classroom methods. It contains the subject matter of the general science course, together with the objectives and principles of organization of general science. The author has provided a brief bibliography of periodical literature of general science.

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The PRESS IMPRINT

November and December 1926

The World and Man

The advance of modern science has revealed a vast store of fascinating facts about the universe in which we live. More discoveries have been made in nearly every branch of science in the past two or three decades than in all the previous history of mankind. Scientists have disclosed a world of the infinitely small in electrons, atoms, and molecules; and of the enormously large in giant suns and galaxies of stars, billions of miles distant. They have looked back millions of years to the origins of worlds, and have traced their history through the geological ages to the present. Myriads of plants and animals have been studied, from the lowliest bacteria and protozoa up to man. Minute investigation of man himself—his origin, the wonders of his body, the development of his intelligence—has yielded astonishing facts. Inanimate matter has revealed marvelous secrets to the modern chemist. The physicist has explained the forces we see about us every day, and the biologist is seeking to explain the very secret of life itself.

To help the inquiring reader in his efforts to keep up with the procession of modern science, sixteen members of the Faculty of the University of Chicago have written *The Nature of the World and of Man*, which E. E. Slosson describes as a book for "those who have not been to college and those who have."

These men, specialists in their fields, are the authors: Forest Ray Moulton, Rollin T. Chamberlin, J Harlen Bretz, Harvey B. Lemon, Julius Stieglitz, Horatio Hackett Newman (the editor), Edwin Oakes Jordan, Merle C. Coulter, Henry Chandler Cowles, Warder C. Allee, Alfred S. Romer, Fay-Cooper Cole, Elliot R. Downing, George W. Bartelmez, Anton J. Carlson, and Charles Hubbard Judd.

Beginning with the outstanding facts about the solar system, each of the sixteen authors has described that phase of development with which he is most familiar: the origin and early stages of the earth; geological processes and the earth's history; the nature of energy and matter; bacteria and their origin; evolution of the plant kingdom, the vertebrates, and the invertebrates; interactions between plants and their environment; the coming of man; organic evolution and the origin of life; human inheritance; structure of man; the living process; and mind in evolution.

Throughout, the authors have emphasized the conception of science as a glowing, living thing inextricably bound up with every human life. With all its multiplicity of authorship, the book has (in the words of the *Chicago Tribune*) "taken on the unity, the coherence, the march of one great epic poem."

Stuart Pratt Sherman said not long ago: "I have a strong impression that our 'average' American is waking up, responding to the new emphasis on 'adult education,' becoming infatuated with the idea of having his education go on as long as he does. He has got wind of the secret that in all the fields of knowledge enormous changes and advances have been made in the last twenty-five years and are still being made at this present hour. His sporting desire to keep up with his times grows keener and the range of his curiosity will soon be encyclopedic."

The popularity of *The Nature of the World and of Man* is evidence of the awakening of the adult public to the possibilities of

further education. For the reader outside the universities the book is a guide to the world of contemporary science; it enables him to form a conception of how the earth came to be, what its place is in the vast physical universe, how life originated; it gives him glimpses of the monsters of early ages; shows him how Cro-Magnon man lived, how atoms are held together in a molecule, how invisible throngs of bacteria surround us, how life came from the sea to the land, why insanity is increasing, how speech developed, how hormones regulate bodily processes. . . . .

The Nature of the World and of Man contains the subject matter of a "survey course" given each year by its authors to a selected group of beginning students at the University of Chicago. The success of the experiment upon which it is based suggests a wide use of this text in similar courses in other institutions to give the beginner a preliminary view of the surrounding world and of his possible function in it.

In this day of increasing specialization and a confusingly large body of human knowledge, orientation toward the more general aspects of the world and of man is a necessity. In the belief of the authors of this text, orientation may best begin with a presentation of what modern science holds as truth. They have therefore attempted to give the student that acquaintance with the general outlines of scientific thought which is the ideal point of departure for his entire intellectual development, and which alone affords him the proper perspective on the world of modern thought. More specialized courses in thinking, man in society, or the arts, may well follow, but this course, being more informational, more inclusive, and easier for the beginner should be the point of departure. *THE NATURE OF THE WORLD AND OF MAN*. By Sixteen Members of the Faculty of the University of Chicago. *$4.00, postpaid $4.15*.

Current American Prose

In a volume of provocative essays, *The Outlook for American Prose*, Joseph Warren Beach searches the current prose of reflection, reminiscence, criticism, and social commentary for auguries of a first-rate style. He judges as stylists the American prose artists who are now in the public eye. Timely and incisive comment from this candid and erudite observer will be not unwelcome to readers who have become aware of the development of American prose style in such books as *Troubadour, Straws and Prayer-Books*, and *A Story-Teller's Story*.

A professed eclectic, and adherent of no particular school or tendency, Mr. Beach seeks the perfect style wherever it may be found. Looking about for American writers of cultivated philosophical prose to compare with Bertrand Russell and Havelock Ellis; biographers to rank with Lytton Strachey; newspaper essayists to place beside Chesterton; and critics as stimulating as Shaw, he advances a gratifying number of claimants to distinction. In Sherwood Anderson, James Branch Cabell, H. L. Mencken, Stuart Pratt Sherman, Paul Rosenfeld, Simeon Strunsky, and Alfred Kreymborg, Mr. Beach finds the most hopeful signs of a distinguished prose art in America, and whether or not you agree with him, you will have to reckon with his arresting dicta on the luminaries of the day.

"Old fashioned or new fashioned, what we want is something first rate," says Mr. Beach. His regard for stylistic perfection leads him to protest against the incoherence of Hergesheimer; the lack of precision in John Dewey; the naïveté of Dreiser; the scientific jargon of Van Wyck Brooks; and the affectations of Van Vechten. Sentimental violence and overuse of such words as "devastating" and "poignant" are charged against Ben Hecht, Hutchinson, Walpole, and Hergesheimer.

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—"*A prose-writer who dares to use the devices of the poet.*"

Mr. Beach finds Gamaliel Bradford too serious minded and turns for lightness of touch to Strunsky and Morley. In Anderson, Cabell, Mencken, and Sherman, he finds the supreme qualities of flavor and individuality, gusto, and precision. Kreymborg's style is "uniformly graceful, delicately tinted."

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Mr. Beach has put to good use a conception of the genuine critical spirit characterized by candor and tolerance. He admits that he has been denied that arrogance which enables a critic to tell at a glance whether or not a writer is one of the immortals. First-rate prose he finds most frequently in the unpretentious styles that slip in between rigid categories.

You will want to read this book for the vigor of its outlook upon American prose and for its timely comment on some of the most interesting figures in modern literature.

H. L. Mencken says in the *American Mercury:* "This is perhaps the first book, written by an American, in which precept is backed up by practice. Mr. Beach writes very effectively, and has much of interest to say. His judgments on the writing of Dreiser, Anderson, Van Vechten and other living Americans are well-informed and plausible." *THE OUTLOOK FOR AMERICAN PROSE.* By Joseph Warren Beach. *$2.50, postpaid $2.60.*

* * *

New Version of the Psalms

For a long time we have needed a translation of the Book of Psalms into the language of our day—a translation that would give the modern reader new insight into the classical rendering of the King James Version, and enable him to see in the Psalms the meaning they originally had. Such a translation is the new version by J. M. Powis Smith, which removes the stumbling-blocks of a centuries-old vocabulary, and divests the verses of unwarranted meanings which a succession of early translators read into them. This version is based upon the official Hebrew text, corrected and emended in accordance with the findings of present-day scholarship.

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